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"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

Volume 23 San Francisco, April, 1937 Number 2

43375

STATE OF CALIFORNIA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF FISH AND GAME

San Francisco, California

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# ELEVEN YEARS OF PROGRESS AT THE CALIFORNIA STATE GAME FARMS [1]

*By* AUGUST BADE
*Superintendent, State Game Farms*
*California Division of Fish and Game*

Eleven years ago the average upland game bird hunter of California knew very little about the sport of pheasant shooting. What little was known then came from men who had visited in either Oregon or Washington or moved to California from there. At that time upland shooting was confined to quail and doves. The great expanse of thousands of acres in the Sacramento and San Joaquin valleys lay as waste lands as far as the hunter was concerned, with the exception of a few weeks in the late fall when duck and goose shooting offered a little sport if one were lucky enough to belong to a club.

During the past three years the sportsmen of California have become acquainted with pheasant shooting in every detail and now each year during the open season, thousands of men, and women, too, find great pleasure in pursuing the wily pheasant.

All of this has come about because eleven years ago actual construction work was begun in building the Yountville State Game Farm. Four years later a second farm was constructed in the south at Chino in San Bernardino County. Each of these farms has a definite area to serve. The Yountville farm takes care of the area north of Bakersfield whereas the Chino farm looks after all the country to the south.

The game farms of California are manned by a competent personnel of Civil Service employees that gives the work stability and keeps it free from unfavorable influence and dominance. And, since all game farm activities are financed from the sale of hunting licenses, these farms are owned by the sportsmen of this State and are being operated for their pleasure and benefit. Inasmuch as these farms are owned by the sportsmen of California it would seem good business, on the part of the sportsmen, to protect and in every way look after the welfare of these birds when they are released in the field and covers of the State to reproduce according to their own choosing.

The methods of production, distribution, and the selection of particular kinds of game birds to be produced and planted, are all worked out with the idea of meeting California conditions as they exist today. These three phases of our game farm program are discussed on the following pages.

## Various Types Produced

With the working out of a better method of production and distribution, California game farms have gone a step further and made

[1] Submitted for publication, March, 1937.

an effort to select a type of bird that was suited in every way to the particular territory to be restocked. In view of these facts and conditions only certain game birds are found fully equipped in every way to qualify on this program. First of all any game bird that stands a chance of making good today must be smart. In checking over the list that experience has approved, we find the following birds qualify: At the head of this list of smart game birds we will place the California valley quail, the ringneck and Mongolian pheasant come next, the Reeves and chukar partridge are a good third, with the Mexican bronze turkey fourth. Ability to reproduce under domestic conditions as well as field and table qualities are taken into account in making this selection.

California valley quail and pheasants are produced on our game farms in about equal proportions. In proof of this statement the records for 1936 show that 21,587 pheasants and 19,843 quail were liberated during the season. Since the game farms were established and a definite program of production and distribution inaugurated on December 7, 1925, these farms have produced and distributed a total of 204,456 game birds. In addition to the native quail, the introduced species described below are propagated at the California game farms.

*Ringneck Pheasant.*

First in this list of introduced birds comes the ringneck pheasant. This bird is well suited to the valleys and agricultural districts but does not do well in the mountains or timbered areas. As a field and table bird he has few equals and the fact that he can be reared under domestic conditions very successfully gives him first place on any game farm program.

*Mongolian Pheasant.*

The Mongolian pheasant, often confused with the ringneck because of the white ring on his neck and general similarity in color and build, is a bird that is better suited to the brush and timbered areas.

*Reeves Pheasant.*

To supplement the blue grouse, it was deemed necessary to find a bird that would fit into the picture of our higher altitudes. The Reeves pheasant, one of the most beautiful of birds as well as the fastest pheasant on the wing, was selected as the successor to the blue grouse. This bird seldom lives in altitudes lower than 2000 feet. Its natural home is in altitudes ranging from 2000 feet up to 8000. The fact that it roosts off the ground is another factor in its favor.

*Wild Turkeys.*

At the present time, 17 of the 48 states have an open season on turkeys. This would indicate that the turkey as a game bird is very much in the picture today and not just a relic of the good old days of Daniel Boone and William Penn. California has many thousands of acres well suited to the Mexican bronze turkey, so that is the one being propagated for stocking purposes in this State. In this connection it might be well to remember that four distinct types of turkeys are found in the United States and that they are all wild and indigenous to this

continent. The Mexican bronze is the largest of the four and was the one that was selected for domestication. Foundation stock for California game farms comes from Carlsbad, New Mexico.

*Chukar Partridge.*

The chukar partridge fits into our scheme of restocking because it naturally lives in barren and desolate regions. In India, its native home, it is known as "the bird that lives on nothing." In other parts of the old world, it is called the "air" partridge for the same reason. If you carefully consider the State of California for a moment you will easily come to the conclusion that we have plenty of room for this game bird. The Chukar partridge meets with the approval of sports-

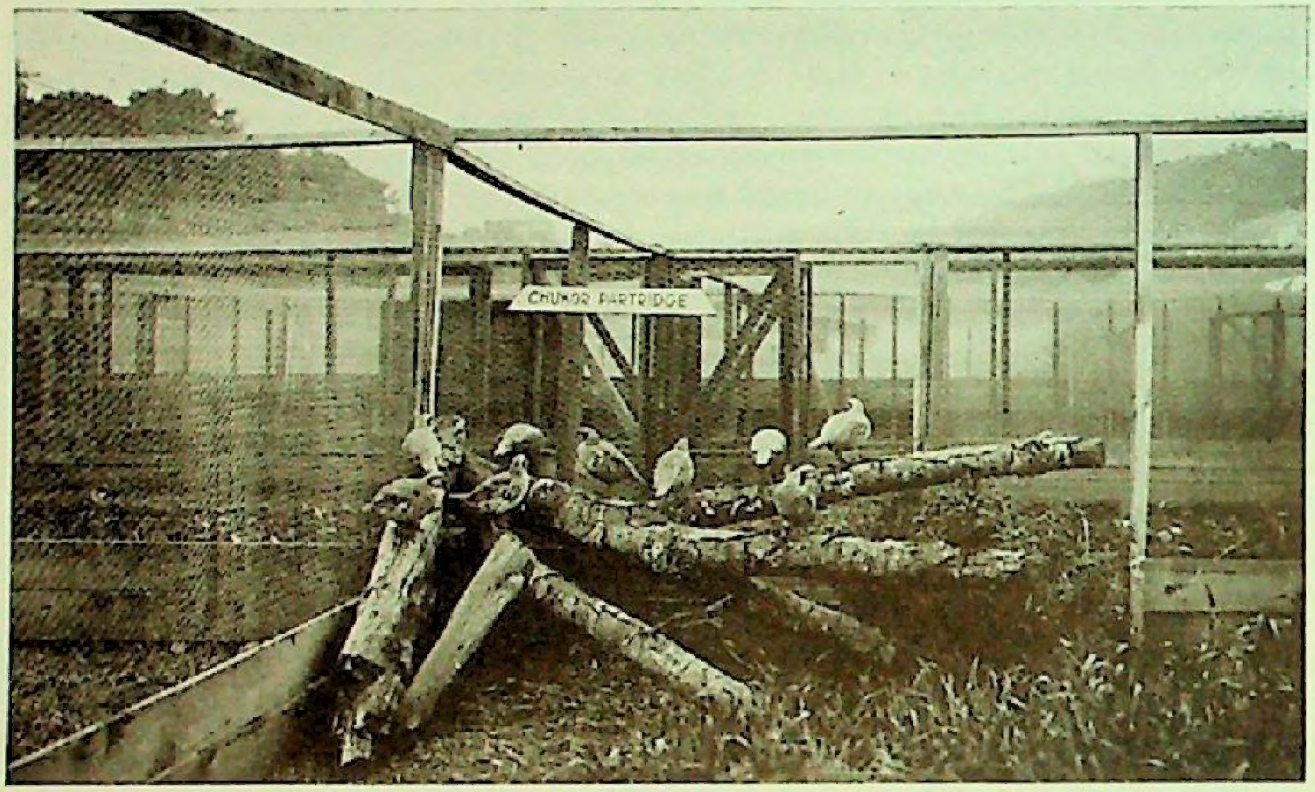


FIG. 1. Adult chukar partridge in holding pen at Yountville State Game Farm. Photograph by author.

men because it is a fine game bird and the best table bird of all the feathered tribe.

So far about 4500 of these birds have been propagated on our game farms and planted in about eighty different sections of the State. The plantings include all types of country from almost sea level to elevations of four or five thousand feet. In general the Sierra range of mountains has been chosen as their home, although many other localities have been included in the initial experiments to find out as soon as possible just where this bird will do the best.

Chukars have reproduced on the floor of the San Joaquin Valley, in Kings Canyon, Mojave Desert, Siskiyou County, and in the desert sections of Kern County. In most cases they have shown a preference for the higher regions where, at the present time, we have no other game bird. As they have been checked as high as 14,000 feet, it looks as though California sportsmen will soon be able to go out into real wide open spaces and still have companionship with a real game bird. These birds are slate grey in color with red legs and bill. They have

black stripes along their sides as well as a black necktie. This color scheme gives them a camouflage that makes them hard to see in any kind of cover. They are about three and one-half times larger than our native valley quail and are faster in flight.

As game farm birds they have already proved their worth as producers. The records of three different hens credit them with the laying of 106, 112, and 136 eggs, respectively, for a single season.

### System of Artificial Incubation and Brooding

For a great many years all types of game birds were reared with the domestic hen as a foster mother. In fact the old reliable domestic hen became the foundation of game bird reproduction. As years passed by and game bird farming became more of a business, it was found that a great many of the domestic poultry diseases were introduced through the agency of the hen to whatever type of game bird was being reared.

Among the more common pathological diseases were tuberculosis, coccidiosis and black head, as well as several different types of intestinal worms.

The factors of disease entered into the business of rearing game birds to such an extent that it was found necessary to devise ways and means of overcoming the disease hazard. It was found that the artificial incubator and brooder met this condition in a most efficient manner, and the more we delve into the interesting subject of artificial incubation and brooding and become familiar with its possibilities, the more we are convinced that the system has come to stay and that game birds of the future will be produced via the incubator and brooder.

There is nothing strange or mysterious about this system. It has been in use since the time of the Egyptians. History proves this statement. Even today the Chinese use primitive methods with good results. One traveler related this interesting story to the writer: While visiting in the Hawaiian Islands he saw three Chinese taking off a hatch of ducks that numbered 14,000. For incubators they used holes dug in the bank of a rice paddy, and common manure furnished the heat. Each hole or incubator contained about 100 eggs and about 90 per cent of the eggs produced ducklings.

Surely if a person can get results with such crude equipment, we ought to do fairly well with what modern engineering has given us in the way of positive sanitary equipment.

The artificial incubator and brooder is to modern game farming what improved methods of production are to industry. The manufacturer is constantly considering ways and means of lowering production costs. Better equipment plus an experienced personnel is the largest factor in increasing production and lowering costs. Clean and healthy working conditions add to the efficiency of workers. Good food and clean sanitary quarters produce better game birds. The modern artificial brooder, where all conditions are under control, is the game breeders' best friend.

The principal claim that we make for artificial methods is this: More and better birds are produced with the same or even less effort. The money invested in equipment, on account of its long life, makes

the capital investment of greater value because of its small depreciation each year. The average life of this equipment is not less than twenty years.

Here is a good example of what we mean in comparing the old method with our present set-up for producing game birds. In 1928 and 1929 we employed 12 men and the production was a little more

FIG. 2. Some of the electric brooder houses at the Yountville State Game Farm. Photograph by author, May, 1936.

than 6000 birds each year. In 1935 with the number of men reduced to 8 and artificial methods used exclusively, the output of birds was 19,789, and they were all disease-free, healthy, strong birds.

In 1928 and 1929 we spent, on the average, the sum of $1,800 for setting hens alone, to say nothing of the cost of picking them up from the farmers that lived within a radius of 20 miles of the farm. At the end of the season these hens were put on the market and brought less than $600. Our outlay then for incubating and brooding was at least $1200 each year or about 20 cents per bird, which does not include the cost of the eggs nor feed for the chicks and hens.

This incubating and brooding cost would not have been such an item if it had not been for the fact that we were producing a lot of diseased birds and fouling the ground upon which future birds would be reared.

As our brooder houses are arranged with 10 rooms to the house, it is easy to check the cost of production by placing a meter on the house to be checked and weighing the feed that the birds consume during the brooding period of 30 days. As these houses accommodate not less than 1000 birds, the check is on a sufficient number to make it authentic. Inasmuch as we know the cost of electric current and the price of feed, the cost of the building, the man hours required to care for the birds, the amount that should be deducted for depreciation on equipment (5 per cent annually) and the price of labor, a fairly accurate production cost sheet can be had.

The cost of these 10-room brooder houses, full concrete foundation for both house and run, is $900. If a depreciation of 5 per cent or $45 is taken, that amount is added to the cost of brooding for the year. And, since each house takes care of three lots of birds for the season, a charge of $15 for depreciation is made against each brooding period.

The incubating and brooding cost of a 30-day-old chick is 12 cents. (See table 1.) To make the story complete we will add the cost of the egg that produces the chick. From our records we find that it takes, on the average, two eggs to produce one good chick. These eggs are valued at eight cents each. From these figures you will see that when the chick is ready for the holding pen it has cost 28 cents.

According to figures turned in to us from several different rearing pen projects where several thousand birds were handled during the season, and a paid attendant was employed, the cost per bird, for this further developing period of six to seven weeks, is 24 cents.

The following tables give the cost details on incubating and brooding chicks to the age of 30 days at the Yountville Game Farm in 1935:

TABLE 1

Cost of Thirty-Day-Old Chicks Brooded in Lots of 1000, with a 90 Per Cent Survival

| | |
|---|---|
| Labor, 96 hrs., @ $0.50 | $48 00 |
| Power, 2450 K.W.H. | 26 00 |
| Depreciation on equipment | 15 00 |
| Feed | 19 29 |
| Total | $108 29 |

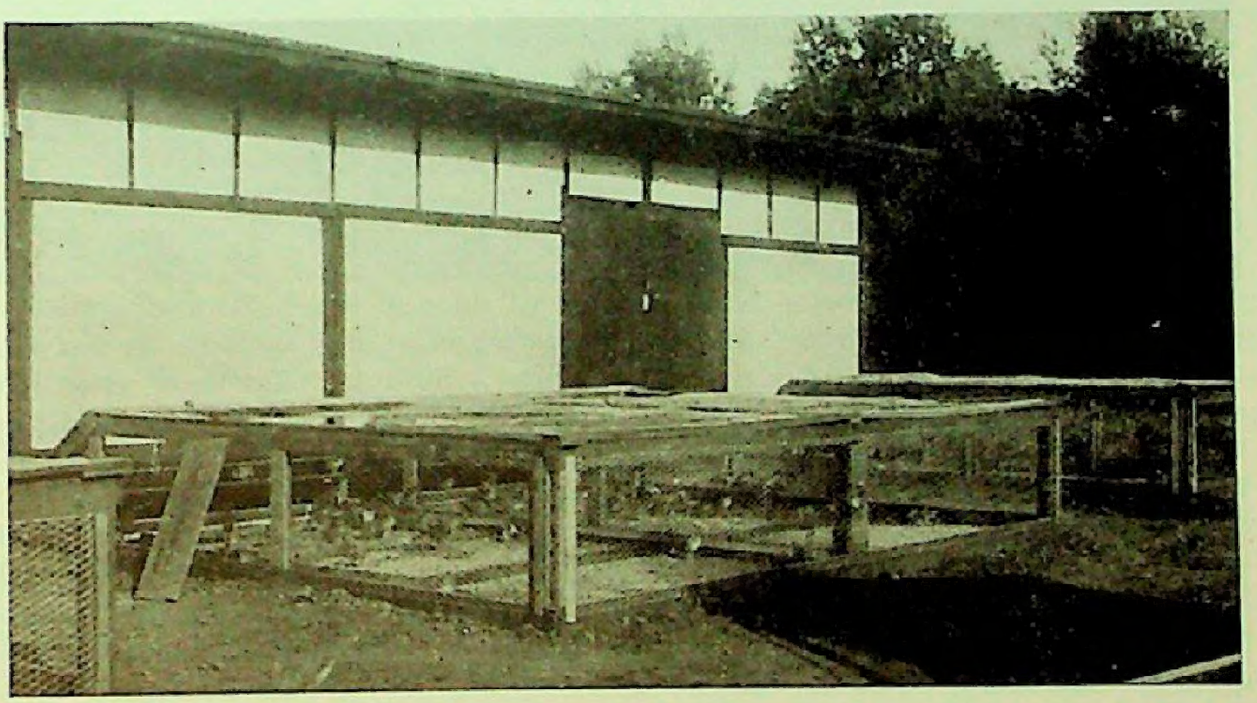

FIG. 3. Electric brooder with week-old pheasant chicks. Photograph by author, Yountsville State Game Farm.

In the foregoing table, the labor item covers all work of incubating, hatching and brooding. The power item covers all the electricity used in these processes. Power costs for artificial incubation will vary with the cost of electricity in the particular localities concerned, and with

the amount of power used for all purposes, as the rate per kilowatt hour decreases as more power is consumed. Power consumption at Yountville is considerable, so the rate is relatively low. Feed costs, which are presented in detail in table 2, apply to the entire lot of chicks which numbered 1000 at the start and 900 at the end of the brooding period of 24 to 30 days.

TABLE 2

Amount of Feed and Cost for 1000 Chicks

| | |
|---|---|
| Game meal, No. 12, 55 lbs., @ $8.60 cwt. | $4 74 |
| Game meal, No. 5, 27 lbs., @ $8.60 cwt. | 2 32 |
| Game chick grain, 36 lbs., @ $2.80 cwt. | 1 10 |
| Rolled hulled barley, 10 lbs., @ $1.10 cwt. | 0 11 |
| Buckwheat grain, 12 lbs., @ $3.50 cwt. | 0 42 |
| Semisolid buttermilk, 12 lbs., @ $3.50 cwt. | 0 42 |
| Hard-boiled eggs, 18 doz., @ $2.75 case | 1 38 |
| Chick growing mash, 400 lbs., @ $2.20 cwt. | 8 80 |
| Total | $19 29 |

## System of Distribution

It is one thing to produce fine, healthy game birds but quite a different matter to get them properly distributed and released into covers where they will get at least a running start in life and have an equal chance to survive and multiply according to their natural inclinations.

In the past decade or two many schemes have been tried in the production and distribution of game birds. Out of this experience two factors seem to stand out in bold relief. The first is that clean, healthy stock must be produced. The disease hazard must be cut to the very minimum. This means the elimination of the domestic hen as a foster mother. Her place must be taken by the incubator and brooder. In many states and localities where the leadership in this particular industry is a little more far seeing, this forward step has already been taken and the artificial incubator and brooder is already considered permanent game farm equipment.

After these birds have been reared to an age when they are ready to be placed in the covers, the second factor that has become apparent out of this experience presents itself. It is obvious that very definite safeguards must be placed around these birds during the first three or four months of life in the open. This brings us to the idea of the closed area or refuge where no hunting of any kind is allowed and where the birds' natural enemies are held in control. When this closed area idea was first advanced, many held to the idea that it would be impossible to secure the necessary ground for this sanctuary. Experience, however, has proven that about 90 per cent of all land owners are more than willing to have their land included in a closed area. In many cases it has been found possible to secure ideal conditions with ample food, water and cover by the combining or pooling of several holdings. The land owner in this case is not only in partnership with the State but has also become a protector in that he is interested in seeing that the birds that have been liberated on his particular ground have the utmost protection.

With the development of this closed area idea has grown up another factor that has proven its worth many times over. Many sportsmen's clubs as well as individuals have become interested to the point that they have been willing to build holding pens for the development of birds up to the point where they are old enough for liberation. In many cases these pens are built on the ground that is being stocked, so that all that is necessary when the time for liberation arrives is to open the gates of the pens, letting the birds walk out and start their period of readjustment unmolested.

In other instances, units of these pens have been sponsored and built by sportsmen's organizations for the rearing and development of birds to be planted in their immediate vicinity. In this case these birds are taken from the rearing pens in crates and transported to the particular ground to be stocked. In California this program has grown

Fig. 4. The Salinas Rod and Gun Club unit of 20 holding pens, Monterey County, California. Photograph by author, July, 1935.

and developed since the building of 12 pens at Cotati, Sonoma County, in 1932, to a system and net-work of pens that now numbers over 1000.

To show more clearly and definitely just what this holding pen idea means, Bakersfield in Kern County can be used as an example. Before any holding pens were built in Kern County we were never able to liberate more than 300 birds in that county during the season. During the first year's operation of 20 holding pens, 1200 birds were liberated, and during the second year when 10 more pens were added to their unit, making 30 in all, 1800 birds were liberated. During the 1935 season, 2017 pheasants, quail and partridges were handled through these pens. In 1936 the number was 2770.

With this additional outlet for birds, the production at our game farms has been increased many fold with very little additional overhead cost. In other words, the holding pen program has been the direct means of reducing the cost of birds liberated in the field.

The birds for these holding pens are hatched in electric incubators and brooded in electric brooders at our game farms. The period of brooding lasts about 30 days, and then the birds are ready to be transported to the holding pens where they are held for another period of about seven weeks, when they are old enough to be liberated.

After the birds are out of the holding pens these pens are cleaned and reconditioned and another allotment of birds is placed in them. It is possible to take three allotments of birds through one of these holding pens when cover crop and other conditions are right. Each pen is 24 feet square and 20 birds are allotted to each pen.

As an additional service to these clubs or groups of individuals who desire to help in the propagation and distribution of game birds, the Bureau of Game Conservation has provided the blueprints and material lists for the building of these pens so that all pens, no matter

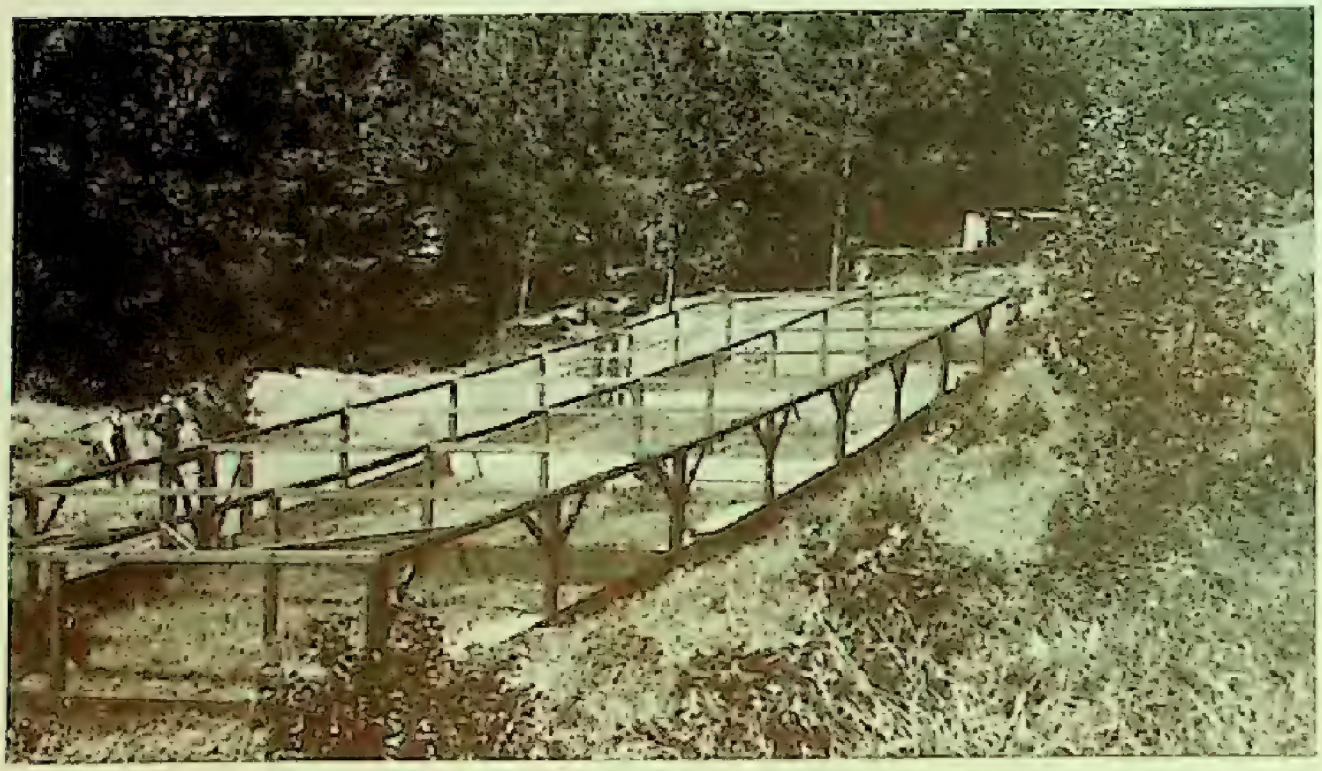

FIG. 5. A small unit of holding pens at Harbin Springs, Lake County, California. Photograph by author, July, 1935.

where located, are of a uniform size and provided with standard equipment. Feeding formulas are also furnished so that the birds are continued on the same diet that they had at the game farm.

With the operation of these 1000 holding pens in various sections of the State, certain facts have come to our attention. Chief among these is the matter of public opinion. It has been found that where these pens are in operation there is a decided sentiment created for better observance of the game laws. In short, the birds belong to the community and consequently command respect from citizens in general, and any poacher who dares to molest them is promptly brought to court.

Here is an example of just what happens when some of these holding pen birds are molested. The town of Dixon, near Sacramento, has a unit of three pens. These pens are located on the grounds of the local cemetery and the birds are cared for by one of the attendants. In 1934 when the birds of the second allotment were given their

liberty, they took refuge in a nearby tract of ground farmed by some aliens. The farmers at once began to shoot the birds. One of the attendants telephoned the local constable and almost before the smoke had cleared three of them were on their way to tell the Justice of the Peace about it. A fine of $75 was assessed on each shooter, and that seemed to have the desired effect. When the Dixon Club held its annual meeting the writer had the pleasure of seeing this episode enacted on the stage of the American Legion Hall before an audience of 200. Every detail of the episode was carried out with the foreign offenders, prosecuting attorney, judge, etc., making up the usual court scene. The remarks by the judge in passing sentence constituted a masterpiece in depicting what a good citizen should be with reference to observance of game laws and more particularly what the attitude of a foreigner should be in the land of his adoption.

While this holding pen program has demonstrated how public sentiment may be created and crystallized in favor of law enforcement, and how it is possible to raise and distribute more game birds, that is not all of the story. Sportsmen are always interested in what becomes of their money and why they are not getting more fish and game for the small amount that each contributes in the way of license money. Here they have the answer as far as birds are concerned.

Our records show that it costs 10 or 12 cents to hatch and brood a quail or pheasant up to the age at which it is ready to go to the holding pen. From data that we have in our records, turned in voluntarily by many of the clubs that are operating holding pens, it costs about 25 cents additional to carry a quail or pheasant on to the age of liberation. If a reasonable allowance is added for capital investment and distribution charges, the cost per bird is still well under a dollar.

Our experience over a period of four years in working with clubs that operate holding pens shows us that these clubs are not only progressive but constructive. Instead of doing a lot of talking and passing resolutions they are producers.

The California system as it stands today consists of artificially produced birds—disease-free and hardy; holding pens, constructed according to our specifications, but paid for and owned by the sportsmen, for the distribution of game birds; and closed areas, made possible by the cooperation of land owners, in which to plant birds where they will have food, water and protection.

# CALIFORNIA SEA LION CENSUS FOR 1936[1]

*By* PAUL BONNOT
*Bureau of Commercial Fisheries*
*Division of Fish and Game*

The two species of sea lions inhabiting the ocean waters within the boundaries of the State of California are Steller's sea lion (*Eumetopias stelleri*) and the California sea lion (*Zalophus californianus*). There is also a true seal (*Phoca*) which occurs in such small numbers as to have little importance.

In common with other so-called predatory animals, the sea lions have received their share of condemnation, especially since the inception of commercial fishing in California. About 1900 the commercial fishermen became so vociferous and their complaints were so numerous that a great many sea lions were killed and an investigation of the food habits of the animals was made.[2] Except for scientific notes and an occasional complaint little was heard of the sea lions until 1926. In that year a professional hunter promoted a great deal of dissatisfaction among the commercial fishermen in an endeavor to have a bounty placed on the animals. So numerous became the complaints that an investigation was begun and in 1927 the first complete census ever taken in California waters was successfully made. The conclusions arrived at in the report[3] of this work are that the sea lion population nowhere approaches the numbers claimed, that although some commercial fish are eaten and fishing gear occasionally damaged, the loss inflicted on the commercial fisheries as a whole is of minor importance. It is pointed out that it would be comparatively easy to exterminate the sea lions, but that having done so, it might be found that there are other and perhaps more harmful organisms on which the sea lions act as such an efficient check that they have not, so far, been a detrimental factor in the commercial fishing industry.

In 1928 and again in 1930 the sea lion census was repeated. During this period the total population remained about the same although the geographical distribution changed somewhat. For a good many years the sea lions apparently have been able to maintain themselves at approximately the same numerical strength although in the last few years, added to the natural checks with which they must cope, are humans in the form of collectors for circuses and zoos, trimming hunters, fishermen who shoot sea lions on general principles, and others who kill them for no reason at all.

For several years the sea lions have not received much attention but during the early part of 1936, it was considered of interest to

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[1] Submitted for publication, November, 1936.

[2] Smith, Hugh M. Report on the inquiry respecting food-fishes and the fishing grounds. U. S. Comm. Fish., Rept. for 1902, pp. 111-142, 1904. (Report on the sea-lion investigations, 1901, pp. 116-119.)

[3] Bonnot, Paul. Report on the seals and sea lions of California, 1928. Calif. Div. Fish and Game, Fish Bull., no. 14, 61 pp., 1928.

ascertain again the status of the animals. In making the previous surveys some sections of the coast were investigated before others and there were gaps of several weeks between the work in one locality and that in another. During the present survey the patrol boat *Albacore* was detailed to examine the entire coast in one cruise. She left Crescent City on June 21, 1936, and completed the survey at the southeast end of San Clemente Island on July 1, touching at all known or suspected rookeries and hauling grounds with the exception of the rookeries at Cape Mendocino and Point Arena. Data for these places were supplied by the respective lightkeepers.

The descriptions and locations of the various rookeries and hauling grounds are set forth at some length in the 1928 report and need not therefore be repeated here.

FIG. 6. Steller's sea lion bull and pups. Photograph by author at Año Nuevo, California, July 2, 1928.

It is at once apparent from the data that little change has occurred in the population and distribution of the Steller's sea lions. The total number of California sea lions has materially increased and a proportionally large number were found in the more northern part of their range, where in previous years only a few stragglers were to be seen. The present breeding range of this species may be said to have been extended, as in former years the most northern rookery used by the Californias was at Point Lobos, south of Monterey Bay, whereas during the present season a small rookery of this species was found associated with the Steller's at Año Nuevo Island, north of Santa Cruz. The California rookery at Frazer Point, Santa Cruz Island, was totally deserted although during the three former surveys it supported a small rookery. Several localities included in the 1927 survey have been

eliminated in subsequent surveys as they were found to be unimportant or nonexistent. Redding Rock, for instance, was reported in 1927 as a rookery of 200 animals, on information derived from fishermen. It was not possible at that time to make a personal inspection. A visit the following year showed that the rock comes straight up from deep water and the only area capable of being used by sea lions would not accommodate more than half a dozen of the animals.

Reference to the table comparing the rookeries for the four seasons in which a census was taken will show how the population shifts from year to year. Some rookeries decrease or disappear and others increase. At Santa Barbara Island there were small rookeries during the first two surveys whereas the next census showed only a few stragglers. During the 1936 season the Santa Barbara Island rookery was the largest California rookery in State waters. A new rookery, not recorded before, is on Bird Rock on the Seventeen-mile Drive at the outer end of the Monterey peninsula. This rock has for years been the hauling ground of a group of seals (*Phoca*) but they have now vacated the rock in favor of the sea lions and have moved to another small rock close by.

The most notable change to be observed among the sea lions is the great increase of adult bulls of both species. Until 1930 adult bulls were comparatively scarce due to the activities of trimming hunters. The trimmings, consisting of the genitalia and gall bladders of adult bulls were sold to the Chinese who manufactured from them an aphrodisiac. Even an earnest desire for sons apparently could not withstand economic pressure and the market for trimmings has become so poor during the last several years that it does not pay to hunt the sea lions. No evidence of systematic hunting was seen and where formerly three or four big herd bulls carried on the necessary breeding in a large rookery composed of several hundred animals, during the present season there were some rookeries with almost as many bulls as cows. The herd bulls have become so courageous that in several places they actually chased humans, an unprecedented occurrence. In previous years the mere appearance of a human near the rookery would cause every animal on it to promptly leave. Despite the great increase in bulls of breeding age little or no fighting was observed. One big bull at the Farallon Islands was badly hurt and profusely bleeding, but whether his hurt originated with another bull or from some other cause was not apparent.

The conclusions of the 1928 report respecting the activities of the sea lions in relation to the commercial fisheries are still valid.

## NUMERICAL COMPARISON OF SEA LION ROOKERIES IN CALIFORNIA FOR YEARS IN WHICH CENSUS WAS TAKEN

| Rookery | Steller's | | | | California | | | |
|---|---|---|---|---|---|---|---|---|
| | 1927 | 1928 | 1930 | 1936 | 1927 | 1928 | 1930 | 1936 |
| St. George Reef | 1,500 | 611 | 700 | 652 | | | | |
| Turtle Rocks | 200 | 200 | | 100 | | | | |
| Cape Mendocino | 700 | 700 | 900 | 700 | | | | |
| Pt. Arena | 300 | 206 | 300 | 142 | | | | |
| Pt. Reyes | | | | 45 | | | | 9 |
| Farallon Is. | 700 | 510 | 900 | 500 | 6 | | 28 | 25 |
| Purissima | 150 | 42 | | 4 | | | | |
| Ano Nuevo | 1,500 | 1,500 | 2,500 | 1,000 | | | | 200 |
| Bird Rock | | | | 25 | | | | 250 |
| Pt. Lobos | | 200 | 49 | 60 | | 70 | 160 | 3 |
| Copper Pt. | | | | | | | | 3 |
| Cape San Martin | | 50 | | | | | | 20 |
| Piedras Blancas | 212 | 100 | 34 | 6 | 86 | 1 | 23 | 35 |
| Lion Rock | 86 | | | 60 | 21 | 6 | | 20 |
| Pecho Rock | 135 | 95 | 300 | 70 | 7 | 75 | | |
| Pt. Sal | | | | 75 | 10 | | | 150 |
| Pt. Arguello | | | | 50 | | 10 | | 20 |
| San Miguel Is. | 595 | 592 | 620 | 1,359 | 149 | 429 | 205 | 520 |
| Sandy Point | 49 | 38 | 12 | 52 | | | | |
| Frazer Pt. | 2 | | 40 | | 93 | 88 | 95 | |
| Gull Is. | 18 | 10 | 5 | | 150 | 105 | 68 | 200 |
| Anacapa Is. | | | | | 34 | 27 | 11 | 11 |
| Santa Barbara Is. | | | | | 125 | 327 | 8 | 600 |
| Castle Rock | | | | | 29 | 23 | 7 | 35 |
| Seal Harbor | 1 | | | | 235 | 228 | 340 | 400 |
| Totals | 6,148 | 4,884 | 6,360 | 4,900 | 915 | 1,389 | 945 | 2,501 |

## POPULATION OF SEA LION ROOKERIES IN CALIFORNIA IN 1936

| Location | Steller's | | | California | | |
|---|---|---|---|---|---|---|
| | Bulls | Cows | Totals | Bulls | Cows | Totals |
| St. George Reef | 131 | 521 | 652 | | | |
| Turtle Rocks | 15 | 85 | 100 | | | |
| Cape Mendocino | 200 | 500 | 700 | | | |
| Pt. Arena | 47 | 95 | 142 | | | |
| Pt. Reyes | | 45 | 45 | 6 | 3 | 9 |
| Farallon Is. | 100 | 400 | 500 | 9 | 16 | 25 |
| Purissima | 4 | | 4 | | | |
| Ano Nuevo Is. | 250 | 750 | 1,000 | 30 | 170 | 200 |
| Bird Rock | 25 | | 25 | 50 | 200 | 250 |
| Pt. Lobos | 10 | 50 | 60 | 3 | | 3 |
| Copper Pt. | | | | | 3 | 3 |
| Cape San Martin | | | | | 20 | 20 |
| Piedras Blancas | 1 | 5 | 6 | 1 | 34 | 35 |
| Lion Rock | 5 | 55 | 60 | 1 | 19 | 20 |
| Pecho Rock | 12 | 58 | 70 | | | |
| Pt. Sal | 30 | 45 | 75 | 50 | 100 | 150 |
| Pt. Arguello | 6 | 44 | 50 | | 20 | 20 |
| San Miguel Is. | 409 | 950 | 1,359 | 126 | 394 | 520 |
| Sandy Pt. | 2 | 50 | 52 | | | |
| Gull Is. | | | | 60 | 140 | 200 |
| Anacapa Is. | | | | 11 | | 11 |
| Santa Barbara Is. | | | | 250 | 350 | 600 |
| Castle Rock | | | | 1 | 34 | 35 |
| Seal Harbor | | | | 50 | 350 | 400 |
| Totals | 1,249 | 3,051 | 4,900 | 648 | 1,853 | 2,501 |

ROOKERIES IN VICINITY OF SAN MIGUEL ISLAND, 1936

| Rookery | Steller's | | | California | | |
|---|---|---|---|---|---|---|
| | Bulls | Cows | Totals | Bulls | Cows | Totals |
| Richardson Rock | 50 | 250 | 300 | | | |
| Wilson Rock | 1 | 8 | 9 | 1 | 19 | 20 |
| Flea Is. | 113 | 387 | 500 | 125 | 375 | 500 |
| Offshore Rock | 25 | 75 | 100 | | | |
| Isthmus Rock | 20 | 30 | 50 | | | |
| Lion Rock | 50 | 50 | 100 | | | |
| Pt. Bennett | 150 | 150 | 300 | | | |
| Totals | 409 | 950 | 1,359 | 126 | 394 | 520 |

# FISH AND GAME STATISTICS[1]

*By* GERALDINE CONNER
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*Division of Fish and Game*

## The New Statistical Building

In January, 1937, when the staff took possession of the new Statistical Building, the move emphasized the recognition which has been accorded the fish and game statistics of the State. The statistical program has stepped into the ranks of a major project of the Division of Fish and Game, functioning for the benefit of the entire Division rather than for the Bureau of Commercial Fisheries alone, wherein it was conceived and developed.

A unit of the California State Fisheries Laboratory, the Statistical Building was erected during 1936 on Terminal Island, under the auspices of the Department of Natural Resources of the State of California and the Works Progress Administration of the United States. Third in a group erected on public land, the architecture follows the lines of the research laboratory and the marine patrol office, which combine to form a mecca for conservationists. The construction is steel frame and concrete, the ground floor area is 38x54 feet and the cost was approximately $30,000. The lower floor of the building was designed as a vast fire-proof vault to be used for filing and storing the great mass of records from which the necessary information is gleaned. The small windows are high in the concrete walls, and a series of drop cords provide electrical light between the stacks of files. The construction of this portion of the building is in keeping with the law which requires certain confidential records be retained indefinitely, accessible for use, but adequately safeguarded.[2] A dumb waiter is provided to carry the heavy files to the work rooms on the floor above, and the power plant for the electrical equipment is housed in a protected compartment.

On the second floor there are provided two great work rooms and three smaller offices. The work rooms (18x27 feet each) were planned to suit the particular needs of the equipment used in this unusual work and to relieve the workers from as much eye and nerve strain as possible. The large windows provide adequate light and these rooms are treated acoustically throughout—floor, walls and ceiling. One room houses the battery of electrically operated Hollerith tabulating equipment, ten pieces of machinery through which the masses of records are punched, verified, sorted and speedily tabulated into concentrated form for the use of the administrators. In an ordinary hard-surfaced room, the

[1] Submitted for publication, March, 1937.
[2] "The commission shall preserve all such triplicate copies of receipts (commercial fisheries) in places adequately safeguarded from loss or destruction, and keep them accessible for reference or research." (Fish and Game Code, 1935-37, division IV, part 2, chapter 5, article 5, section 1096.)

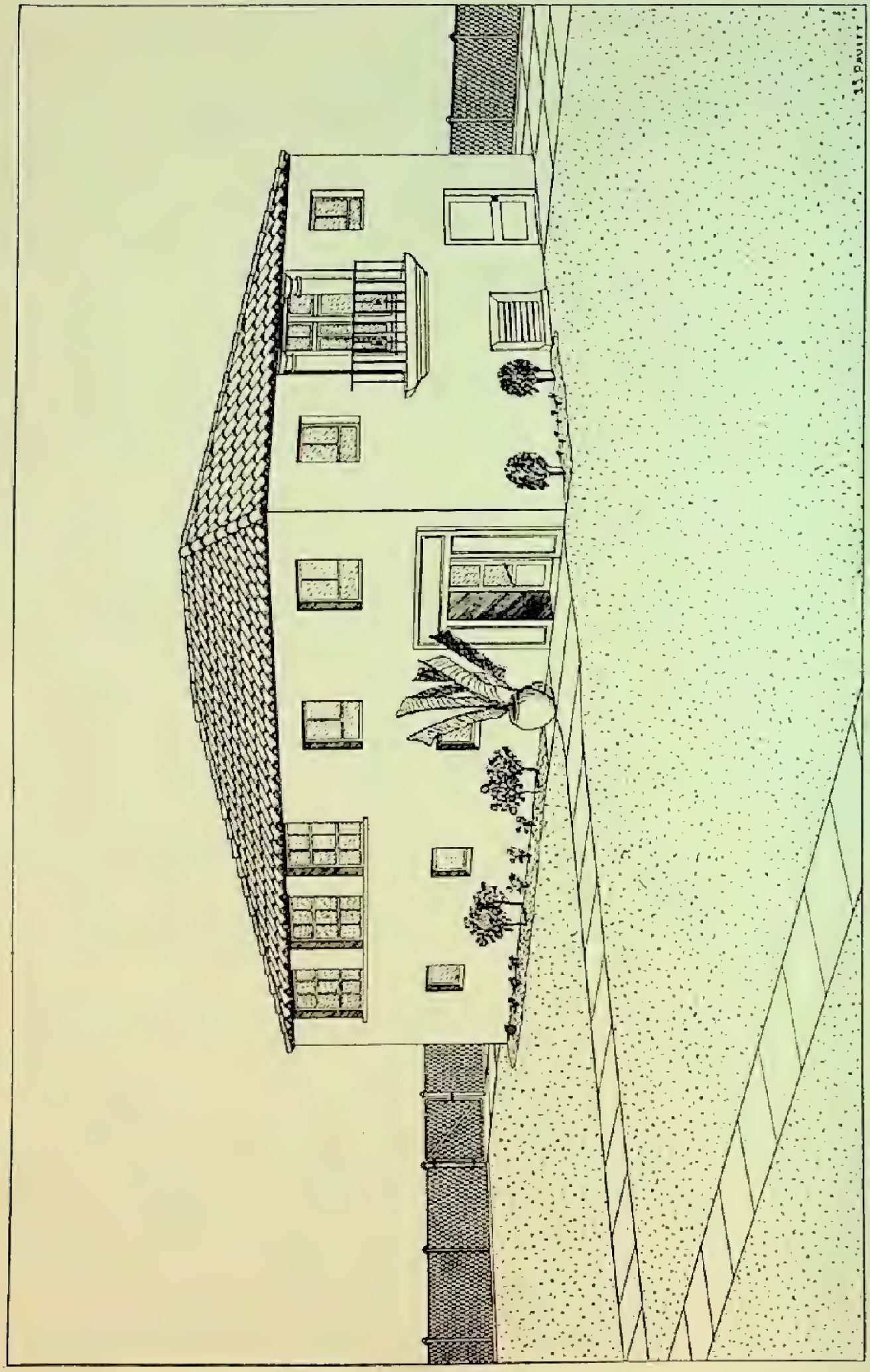

Fig. 7. The new statistical building of the California State Fisheries Laboratory at Terminal Island.

clatter would be brain-splitting and detrimental to a job which requires steady concentration on figures. The second work room provides a quiet haven where the operators and clerks may code, file or prepare the work for the machines.

Two of the offices are used for the supervisory staff and one room is set aside for the use of visiting members of our organization or for the frequent visitors who come from all over the world to use the laboratory's fisheries library and to work with the research or statistical staff.

## Types of Statistics

So much for the new building, now to answer the ever recurring questions concerning the need for such an elaborate setting and large staff and the uses to which the statistics are put. To begin with, we tabulate several types of statistics, the varying degrees of completeness depending upon the method of gathering the information, the required results and the length of time the program has been operating. One group of records forms the foundation for biological research, where accuracy of every item is essential and complete data on each area necessary. The collection of this material is backed by laws with heavy penalties for non-compliance and drawn to protect the confidential nature of the individual record involved.[3] In this class falls the commercial fisheries triplicate receipt system. Nearing that perfection is the deer tag record. Next we have the marine sport catch system, complete for ocean fishing from the pleasure boats and barges which are regulated by permit, and since 1935 have been required by law to supply records of the catch and number of people fishing. The sport fishing records are incomplete for the inland waterways where lack of understanding and a spirit of resentment for governmental inquiry have prevented the gathering of complete records. However, in many cases where the pleasure boat owners of inland areas appreciate the value to themselves of the results which will come from the statistics, voluntary records are being supplied for our work. Last come the general estimates, surveys based on the inquiry: "What did you get last year?" which is asked of every hunter and sport fisherman on a questionnaire attached to his application for a license. These statistics are in the formative stage. Of what value they will be to the administrators can not be foretold after the first year's tabulations. The chief objective in all cases is to gain a measure of the abundance and availability of the wildlife and to note the changes over a long period of years. The perfected statistics are giving indisputable evidence of what is happening. The tests being made with the newer pieces of work will prove their value, pointing the way to improvement or modification.

### Commercial Fisheries.

About twenty years ago when the Bureau of Commercial Fisheries was in its infancy and endeavoring to plan for the intelligent management of a natural resource belonging to the people of the State, one of

[3] "The receipts, reports or other records filed with the commission pursuant to the provisions of this article, and the information contained therein shall be confidential and the records shall not be public records, and in so far as possible, the information contained in the records shall be compiled or published as summaries so as not to disclose the individual record or business of any person, firm or corporation." (Fish and Game Code, section 1096.5.)

the first steps necessary was to gain information concerning the extent of the fisheries. Proper management and laws depended upon this knowledge. The fish in the sea could not be counted but the amount of fish landed, measured against the amount of effort it took to get them, would, over a period of years, give an adequate working basis. That meant statistics—great masses of figures, boiled down to a few definite facts.

The first records were estimates, but they were a start, better than nothing. Gradually they improved. The enthusiasm of the biologists and statistical staff spread to the administrators, when in actual practice the results of the work proved a rock foundation to combat dangerous legislation and harmful fishing activities. The volume was staggering but the methods of handling improved.

In 1931, mechanical methods were introduced for handling the data and by this time recognition from outside the State and even outside the United States placed California in an enviable position as far as commercial fisheries statistics were concerned. The triplicate receipt system, vessel logs, boat registrations and license applications provide a complete and accurate statistical picture of this State's commercial fisheries. The results, handled by a trained staff of research workers, are conservative and dependable. It is the excellent planning and the careful use of the confidential records of the fishing industry that have enabled this program to reach its high degree of efficiency. Naturally trial and error over twenty years have weeded out its weak points.

In addition to the general commercial fisheries statistics, special records analyze the happenings in the individual fisheries—sardines, tuna, mackerel and flatfishes, each directed by the scientist conducting the biological study. For years, cooperative programs with other governmental organizations have been carried on with the regular routine.

### Deer Tag Record.

The Bureau of Game Conservation is concerned with the management of the deer crop in the State. In 1927, legal provision was made for the hunters to report each deer killed with details concerning it to the Division, but the statistical analysis was slow and difficult. The value of the record lay in knowing as the deer season progressed in which county the hunters were making the greatest inroads into the deer, where the season was too early or too late, and where the smaller animals were being killed. The tag provided the information. The commercial fisheries department had the statistical machinery for handling such a record. In 1932, the first tabulations were made at the fisheries laboratory on the yearly kill of some 20,000 to 25,000 deer. From that year on, under the supervision of the statistical staff, deer clerks have turned out the ever improving deer kill record.

The value of this work to the game conservationists is best expressed when we cite the fact that for the 1936 deer season, the U. S. Forest Service called upon the statistical staff to direct a cooperative program. Added measurements which forest rangers had taken, on a sample of 10,000 deer killed in the 18 national forests of the State, were tabulated for analysis.

### Hunting License Applications.

Success with the deer record brought forth an ambitious program of general game statistics for administrative purposes. In 1935 hunters were requested to give an estimate of the game they had killed the preceding year, on a statistical questionnaire attached to the hunting license applications. This record was not expected to be letter perfect, it was merely to give the Division a general survey of game conditions in the State. Approximately 200,000 hunters apply for hunting licenses in the State each year and it was gratifying to find that 50 per cent of these sportsmen were interested enough to give a return on this questionnaire the first year. The results were tabulated and some of the estimates obtained revealed surprising facts about the game bird and mammal populations in certain areas of the State. Moreover, what 100,000 hunters reported last year will have some weight when measured against another 100,000 returns for this year and the years following. We had some excellent county by county comparisons which showed such facts as where the most doves were killed, where the plants of pheasants were giving the best returns and where coyotes were the thickest. Augmented by field observations, such information helps the patrol force, the game farms and the war on predators.

Besides the request for statistics the questionnaire carried a space for "Remarks." Here the hunter had a chance to "blow off steam." Some remarks were vitriolic, some were stupid, but there were constructive suggestions made by intelligent sportsmen interested in the welfare of the game. A few theme songs from given areas, where the laws might bear improvement, will be given full consideration.

### Marine Sport Catch.

The marine sport catch has been carefully planned and several years of educational work preceded the actual statistical program. The results of this care produced usable records from a group of pleasure boat and barge owners the first year. The preliminary preparations will simplify the enactment of proper laws to insure the collection of similar records from inland waters in the future.

The thousands of marine sport fishermen are drawing more heavily each year upon the same supply as the commercial fishermen, protesting the shortage of desirable species with little realization of the toll they are taking. So closely allied are these two types of fishing that it will be impossible much longer to administer to the commercial fisheries without statistical information concerning the marine sport catch. The volume is greater than is realized and in many cases exceeds the take of the commercial boats.

### Angling License Applications.

Following the lines of the questionnaire attached to the hunting license applications, the record on the angling license applications is merely an estimate. The results obtained from the first year's returns given by 50 per cent of the anglers have shown us that the records will furnish us with much of the general information we desire, although many of the individual reports obviously have been affected by reticence, exaggeration or failure to remember. When analysed

with due regard to the source, the data given on the applications will prove to be of real value.

### Interpretation of Material

From 1931 until 1937 the statistical work has snowballed until the volume is five or six times greater than it was when the mechanical tabulating devices were installed. The acknowledgment of the success of the commercial fisheries statistical program planned with such circumspection has led to an enthusiasm for statistics which is both gratifying and precarious. Statistics of our fish and game to be of full value need the interpretation of experts with an understanding of the individual species, local conditions and the degree of error in the material collected.

Because we are producing tabulations in varying degrees of perfection there is the danger of misjudging an estimate as a finished piece of evidence, and confusing scientifically correct data with superficial pieces of work. It is our present endeavor to avoid further expansion until all of the work in hand may be made impeccable. With the advantage of working quarters explicitly suited to the work we are in a position for the first time to get the maximum value from the available material.

# MAGNETIC RECOVERY OF FISH TAGS[1]

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The usual method of tracing migrations of fish or other animals is to tag or mark as many healthy individuals as possible in a way which will be readily noticed. Fish are marked by clipping fins, by tattooing and by tagging.

Fin clipping is generally used when the fish to be marked are very young—for instance, young salmon migrating down stream are sometimes marked in this way. The method is fast and if properly done it is permanent. The disadvantages are many. It is not very noticeable and if noticed may be attributed to a seal bite or some similar accident. It may seem too troublesome to the finder to hunt up the proper authority before the fish spoils or properly to preserve his find in case he chooses to send it in. Fin clipping can not be scattered over a large number of places and dates as a fish does not have many fins and there are not enough distinctive ways of clipping them to keep separate very many batches of fish.

Tattooing is more or less permanent and each fish can be given a serial number. However, writing out a large number with a tattooing needle is very slow. The way in which tattooing has proved most valuable is in conspicuously marking a tagged fish on which the tag alone would not be readily noticed. For example, halibut are tagged on the gill cover on the upper side. A tag on the lower gill cover would probably be scraped against the ocean bottom until it worked loose. However, the halibut fishermen nearly always slide the fish aboard with the bottom side up. A tattoo mark on the bottom side thus keeps the tag from passing unnoticed.

Tagging is the most commonly used method of fish marking. The tags are easily applied, they are serially numbered so that a record can be kept of each fish, and it is a simple matter for the finder to drop a tag in an envelope and mail it to the proper authorities with a statement of when and where the fish was taken. The chief disadvantage is that the more conspicuous tags are rather readily lost by the fish, more so by some species than by others.

There are many types of tags. Some are large, some small, some clip on fins or gill covers, some consist of two buttons held together by a wire which passes through the back muscles of the fish. The tag having the least chance of being lost is a flat piece of metal or celluloid which is placed inside the body cavity of the fish through a small slit. Obviously, this type is also the most inconspicuous.

No matter what sort of marking is used, the success of the whole plan hinges on one thing. Neither tags, clipped fins, tattoo marks,

[1] Submitted for publication, March, 1937.

nor any combination of these can succeed if no one notices the markings.

There are some species of fish with which the chances of any one noticing a marked individual are slim indeed. These are fish that are caught by the boatload, unloaded with huge dip nets a thousand or two at a time, and either cleaned and beheaded by machinery or else carried on a mechanical conveyor direct to the fish meal plant. Obviously fishermen and cannery workers are not at all likely to notice one tagged fish in the middle of a pile containing many tons of untagged ones. Two species which are handled in this way are the subjects of tagging experiments: the Alaska herring and the California sardine. Nearly all the herring and sardines, or the offal therefrom, pass through reduction plants and it is in these plants that recovery of tags must be made.

George Rounsefell, of the U. S. Bureau of Fisheries, who was doing research on the Alaska herring, conceived and carried out the idea of using tags which could be recovered by magnetic methods. Various types, sizes and materials were tried. The one finally selected was an internal tag of nickel plated steel measuring about $\frac{3}{4} \times \frac{1}{4} \times \frac{1}{25}$ inches (19 x 4 x 1 mm.). This was large enough to be readily noticed and flat so the magnetic collector could get a good grip on it. Corrosion is not a serious problem when internal tags are used—apparently the body tissues of the fish use up all the available oxygen. At first, the tags were recovered after the fish had been made into meal. This was done with comparatively simple equipment but had some serious disadvantages. It was impossible to check on the growth or condition of the fish and, far worse, the tags were likely to "hang up" somewhere in the reduction plant for days or even weeks. During this period, the fishing fleet might have fished in several different areas. As a result this method could not give accurate information about *short* migrations. For long migrations, it was perfectly satisfactory, as the herring boats never operate any distance from the plants. To overcome the difficulties just mentioned there has been installed some far more elaborate equipment which recovers the tagged fish as they pass down a flume from the boat to the plant.

In the case of the California sardine, the details about short migrations are of minor importance and there are so many plants that it is out of the question to equip all of them with the more elaborate collectors and to supply enough men to keep the close watch which such equipment demands.

As a result, when the California Division of Fish and Game started its sardine tagging program it was decided to use the simpler devices first mentioned. These are known as magnetic separators. There are many types used to separate magnetic from non-magnetic materials in factories, mines and mills all over the country. The tags decided upon were internal ones of nickel plated steel about the same size as those designed by Rounsefell.

After a careful examination of various types of magnetic separators, it was decided that the best for use in the California plants was one of the smallest and simplest. It was designed for use in flour mills to keep stray pieces of iron out of the grinder. It consists of a power-

ful electro-magnet which magnetizes an iron plate. This plate forms part of the bottom of an enclosed chute. Grain (or fish meal) passes down the chute and into the grinder. Nails, nuts, bolts, horse shoes, and monkey wrenches do not—thus saving much wear and tear on the grinder, and in the case of flour mills, many explosions. (Under some conditions, flour dust is highly explosive and plenty of sparks as well as some rather terrifying sounds are provided by a grinder hard at work on a half-inch bolt.) These small separators, though designed for grain, will work satisfactorily on almost any substance which is in fairly small pieces, does not form into large lumps, which will readily slide down the chute, and which does not contain so much "tramp" iron that the magnet is overloaded.

A brief examination of a fish meal plant will reveal that there is only one stage in the manufacturing process during which the tags can be extracted with this type of magnet. Whole fish, as well as fish heads and offal from the cannery, enter the plant on a conveyor, go into a cooker, from there to a press which squeezes out the oil, then into the hasher (a monstrous meat grinder which is so coarse that tags pass through it uninjured), then into the dryer. From the dryer, the meal emerges dry and well broken up and passes by means of a conveyor into the grinder which pulverizes it. Not until it has emerged from the dryer is the meal in such condition that the tags can be readily extracted from it. Obviously then, the one satisfactory place for the magnet is between the dryer and the grinder.

Having determined what equipment was necessary and how it should be installed, the Division of Fish and Game obtained the cooperation of the cannery owners in the matter of installation. The benefits to the canner, which would arise from keeping tramp iron out of the grinder, were apparent. Many canners realized that the rapid wearing out of expensive grinder screens was largely due to tramp iron, others did not believe that enough went through their plants to cause any great damage, but nearly all were willing to install and operate at their expense any magnetic separator which the State would supply. A few had already installed their own separators, and a somewhat larger number had plants so designed that an installation would have been too difficult and expensive to be practical.

This much having been learned, a single separator was ordered, installed under the supervision of an expert, and given time to prove its merit. A few minor changes in the installation were necessary due to the differences between fish meal and grain. Then, the "bugs" having been ironed out and the apparatus proven satisfactory, 25 more were purchased by the Division of Fish and Game and installed at San Francisco, Monterey, San Pedro and San Diego.

The structure of the magnet and the usual method of installing it are shown in figure 8. The coil is roughly 5 inches long by 6 inches in diameter. There is a heavy iron core with two end plates. Fastened across the end plates is a sheet of iron over which the meal slides. This sheet is about 8x16 inches. Set into it are a lip and a trap door. The lip is simply a bent-over portion of one end plate which passes through a hole in the floor plate. The upper edge of the lip slopes gradually away from the floor plate; the lower edge is quite sharp and so forms a space where iron can lodge and not block the flow of meal. Inciden-

tally, the pull of the magnet is strongest at this point. Below the magnet proper is a trap door in the floor plate. The theory is that when the current is turned on the door is held shut by the pull of the magnet, and when the current is cut off the weight of the door swings it open and the magnet's load of tramp iron and fish tags goes through the door instead of into the grinder. The trap door probably works when the separator is used on grain, but fish meal forms a fine dust which gets—among other places—into the hinges of the trap door and gums them up enough so that the trap can not be trusted to work automatically.

As the magnets require direct current, and as without exception the canneries and reduction plants in California are supplied only with alternating current, it has been necessary in every case to supply a rectifier with the magnet. These are all of the copper oxide two-stack

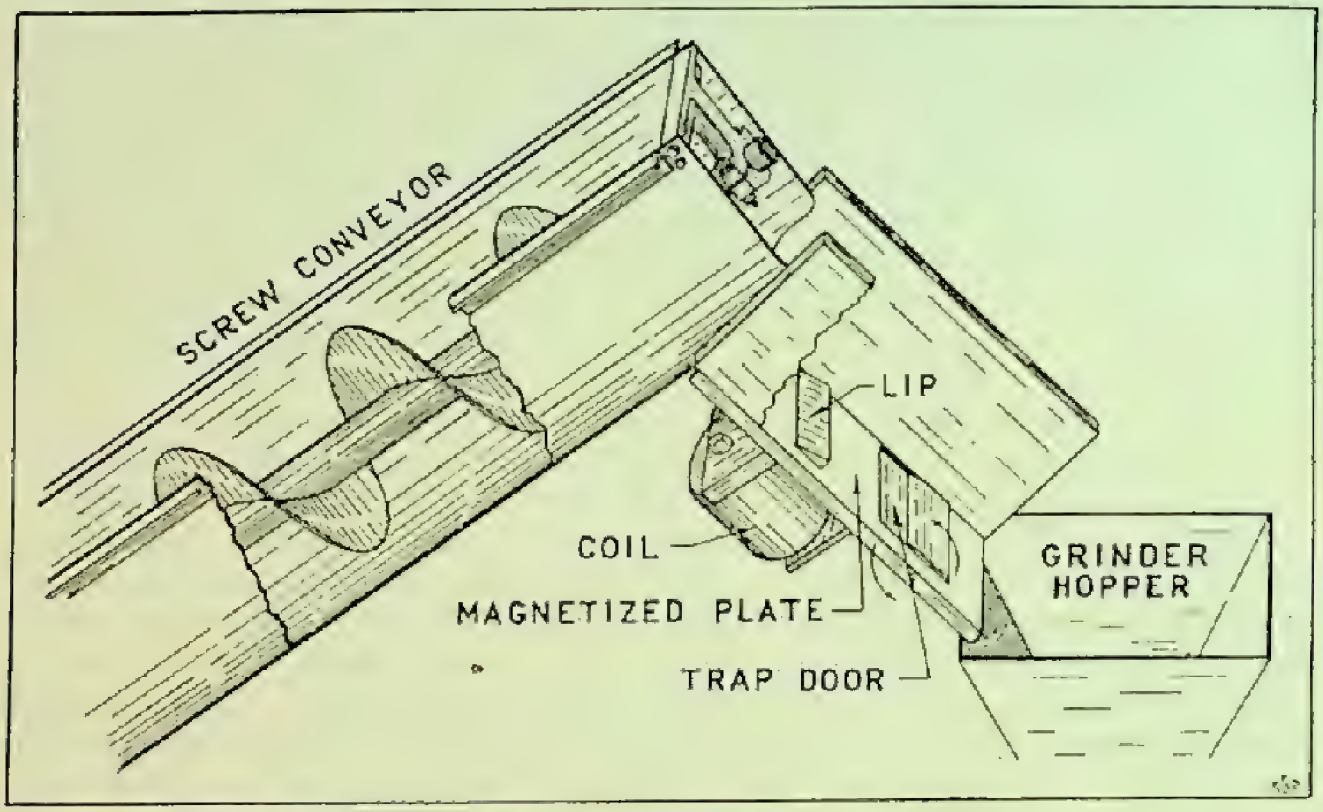


Fig. 8. Diagram of magnetic separator in place.

type and were furnished by the same firm which made the magnets. Although the magnets have given satisfaction, the rectifiers have given considerable trouble.

The installation of the magnets was done by the mechanics at the canneries and reduction plants under the general direction of a member of the California Division of Fish and Game. Installing a magnet is in many cases a very simple matter. There are a few rules to be followed and after that it is a case of mechanical ingenuity in finishing the job. The floor plate should be set at an angle somewhere between 45° and 70°. If the slope is less than 45°, the first piece of iron that comes along stops as soon as it hits the upper edge of the floor plate; the meal is moving slowly and does not have enough force to slide the iron over the edge of the lip, but tends to pile up back of it instead; if there is much iron the chute is soon blocked. On the other hand if the angle is greater than 70°, meal and iron are practically falling and some of the iron may not be caught at all. An angle of about 50° to

55° seems to be best—the meal will not pile up, but goes slowly enough so that the magnet is able to catch and hold all iron.

The sides of the chute should be of non-magnetic material. If they are of iron they will become strongly magnetized near the magnet, less so at a distance from it, so that some iron may stick to the side, be slid by the meal slowly along the side, past the magnet and down to a place where the magnetism is no longer great enough to hold it.

In some plants a good installation can be easily made; in others, space is so limited that *any* installation becomes very difficult indeed. The most common trouble is that there is not 16 inches of space between the bottom of the conveyor and the top of the grinder. Occasionally it is a simple matter to raise the conveyor, but usually it is necessary to cut down the magnet instead. This operation is a simple one: the floor plate is cut off between the trap door and the coil, and the trap is discarded. This is no great loss since as mentioned above, it does not work any too well in a fish meal plant. Additional space can sometimes be gained by cutting a notch in the grinder top—but most grinders are so designed that this is not advisable. Occasionally, when everything else is impractical, it is possible to install the magnet between the dryer and the conveyor or in the bottom of the dryer just above the outlet. A magnet in either of these places is very inaccessible and such installations should be used only as a matter of last resort.

No matter what type of installation is used, there should be a switch placed within reach of the magnet to make removal of tramp iron as simple as possible.

The quality of installation has varied widely. In one case, wood was so neatly mounted all around the magnet that a cabinet maker might have been proud of the job, and then this wood was covered with heavy iron—a precision fit with all joints neatly welded. In the other extreme, one mechanic did such a poor job that the magnet was ruined and had to be recalled. Most of the installations were neat workmanlike jobs allowing the magnet to operate at full efficiency. Some mechanics, on the other hand, were so used to thinking in terms of iron that they disregarded instructions to use some non-magnetic material for the lining of the sides of the chute and thus reduced the efficiency of the magnet to some extent.

The method of "clearing" is first to divert the flow of meal—usually by opening a dump gate in the conveyor and letting the meal drop onto the floor, then open the trap door, shut off the current, brush off any iron that does not drop off, turn on the current, close the trap door if it sticks open, start the flow of meal again, and shovel up what is on the floor. Instead of using the trap door, some operators prefer to hold a cigar box under the magnet when the current is cut off. When a separator is minus its trap door this is the only method which can be used.

Everything that comes off the magnet is saved by the plant operator until collected by a member of the Division of Fish and Game. It is then screened to remove fish meal and small pieces of iron, and is then laboriously picked over for tags. The amount of metal collected at the average cannery usually ranges from a pint to a quart per week, but may run higher if any great amount of repair work has been done. Some of the more common things collected are: nails, fish hooks,

nuts, bolts, ball bearings, scraps of "tin," bottle caps and unidentifiable fragments usually very small but occasionally as large as two or three pounds. Some rarer items are: screw drivers, wrenches, knives, and once a small grease gun in perfect working order. Workmen invariably drop such things as those mentioned, all of which seem to have a sort of homing instinct which guides them to the reduction plant. Plants which do reducing only (i. e., no canning) have much less equipment from which parts are apt to drop and fewer employees to drop things, hence much less tramp iron.

Plant owners are glad to have this tramp iron problem solved, and most of them are more than satisfied with the magnets. In several plants the owner has said that he would be glad to buy the magnet or would replace it with a new one if the State should want to discontinue this work.

The number of tags collected by all 29 magnets (26 State-owned and 3 private) usually ranges from none to 5 or 6 per week. On one gala occasion a single cannery produced 24 tags in one week—but that record has never been approached.[2]

On the whole, our present method of tag collecting seems to be entirely satisfactory. It would be to our advantage to be able to collect the tagged fish instead of just the tag, but at present the benefits do not seem to be worth even a small part of either the extra labor or the extra equipment, which would be needed to make this possible.

## REFERENCES

Dahlgren, Edwin H.

1936. Further developments in the tagging of the Pacific herring, *Clupea pallasii*. Cons. Perm. Int. Explor. Mer, Journ., vol. 11, no. 2, pp. 229-247, 7 figs.

Rounsefell, George A., and Dahlgren, Edwin H.

1933. Tagging experiments on the Pacific herring, *Clupea pallasii*. Cons. Perm. Int. Explor. Mer, Journ., vol. 8, no. 3, pp. 371-384, 6 figs.

1935. Races of herring, *Clupea pallasii*, in southeastern Alaska. U. S. Bur. Fish., Bull., vol. 48, no. 17. pp. 119-141, 10 figs.

[2] By March, 1937, the average number of tags recovered had risen to over 30 per week. The sardine season closed March 31.

# TAGGING PACIFIC MACKEREL[1]

*By* DONALD H. FRY, JR.
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In 1928 the canning of Pacific mackerel suddenly became a large industry, operating on the well-established American plan which assumes all natural resources are inexhaustible until they are practically exhausted. Such huge tonnages of mackerel have been taken that there is every reason to suppose the supply will not last unless some well thought out plan of regulation is put into effect. Tagging is a necessary part of the research on which such a plan must be based. Consequently, the California Division of Fish and Game, through its fisheries laboratory, has instituted a mackerel tagging program.

Canning operations are what endanger the fish. The men who fish for sport and for the fresh fish markets take so little by comparison that in a depletion study, their efforts can be practically disregarded. There has been some canning at Monterey in central California and some at Ensenada, Lower California, but the really heavy fishing has been in southern California, from Ventura south to the international line—a distance of about 160 miles. During the last few years the quantities taken in this small area have been far larger than the mackerel landings of the entire Atlantic coast—and the Atlantic fishery is a heavy one. Obviously it is not safe to assume blindly that this small area is actually producing more mackerel than the huge fishing grounds of the Atlantic—and if southern California is not producing all its fish, where are they coming from? The range of the species is from Vancouver Island to the tip of Lower California. Are the canneries taking fish from this entire length of coast? The fishing grounds of all this coast, by the way, are only about 37 per cent as large as the mackerel fishing grounds of the Atlantic. There is known to be much heavier spawning off Lower California than off southern California. Is Mexico producing our fish? Does a large part of our local population move south into Mexican waters to spawn? Is our population merely the overflow from a much larger Mexican one? Do the two regions have distinct populations with little or no migration back and forth? If we destroy our own population, will more fish soon move in from somewhere else, will there be other populations to the north and south of us which will *not* move in, or will we have depleted the mackerel population of the entire Pacific coast? These vital questions and many others can best be answered by tagging large numbers of fish over a wide area.

Tagging consists of fastening to the fish some sort of tag, band or label so that it can be definitely identified at a later date, turning it loose, and waiting for some one to report where it was next seen. If

[1] Submitted for publication, March, 1937.

the movements of enough individuals can be checked in this manner it is possible to obtain very definite knowledge of the movements of the entire race.

In this region there are two methods of finding tagged mackerel. The obvious and time honored way is for some fisherman to notice the tag on one of his catches and either send or take it to the laboratory carrying on the investigation. This method is fairly satisfactory in the case of mackerel, because numbers of these fish are caught by sportsmen and market fishermen who would be apt to see the tags. A more recent method is to use magnetic tags and recover them with magnetic collectors. This method is more likely to get the tags from those mackerel caught in large scale cannery operations, where fishermen and workers handle so many fish they do not look at any closely.

When the California Division of Fish and Game started its sardine tagging program, magnets were installed in fish canneries and reduction plants all over the State.[2] The sardine and mackerel tagging programs were started about the same time. The magnets were not absolutely essential to the success of the mackerel work, but they were already being installed and there was every reason to take advantage of them, so the mackerel tags were made of pure nickel which is magnetic and does not corrode in sea water.

As an inducement to fishermen to let us have any tagged fish they may take we are offering 75 cents for the return of each mackerel with tag in place, or 50 cents for the tag alone. Full information as to where and when the fish was taken must accompany the tag. Fish or tag may be taken to the California State Fisheries Laboratory, Terminal Island, or the San Diego or Monterey offices of the Division of Fish and Game; or mailed to the California State Fisheries Laboratory.

By offering the extra 25 cents for the fish, we have been able to keep track of the way in which the tags are staying in place, and we may eventually accumulate some valuable information on growth rate. Illustrated notices are posted in most places where fishermen are apt to land mackerel, such as canneries, markets and pleasure fishing piers.

### Types of Tag Used

The type of tag originally chosen is shown in figure 9. It is of the strap type and is designed to fasten onto the gill cover. It is applied with a special pair of pliers which forces the point through the gill cover and locks the tag shut. When closed the tag measures $\frac{1}{4}$ of an inch wide by $\frac{5}{8}$ of an inch long.

Up to the present time a bright red celluloid band has been placed around one end of each tag to make it more readily noticeable, particularly in the dim light of a cannery. It has become evident that the workers are almost as mechanical in their motions as the cleaning machines themselves, and do not notice the tags even when the bands are in place. The bands may be abandoned in the future for this reason and also because they doubtless increase the chances of a fish being singled out by a predator as well as being an irritant to the fish.

When we first obtained the strap tags, we had trouble with a slight wire edge which was present on all of them. After sending the tags

[2] See "Magnetic recovery of fish tags," pp. 119-124.

back and getting a slight improvement we started to use them. It soon became painfully evident that they were very irritating to the fish, and in many cases were enlarging the hole in the gill cover and falling off. Since making this unpleasant discovery, we have smoothed each tag before using. A drum, 9 inches in diameter by 2 feet long, was given a ridged inside surface by nailing on ¾-inch half round strips of wood. There were 16 such strips, each one going the full inside length of the drum. The whole was lined with fine emery cloth and revolved on a small lathe at 55 r.p.m. A four to eight hours' ride in this device leaves a batch of tags in excellent condition. The ridges in the drum are necessary—otherwise, the tags get worn too much on the ends and not

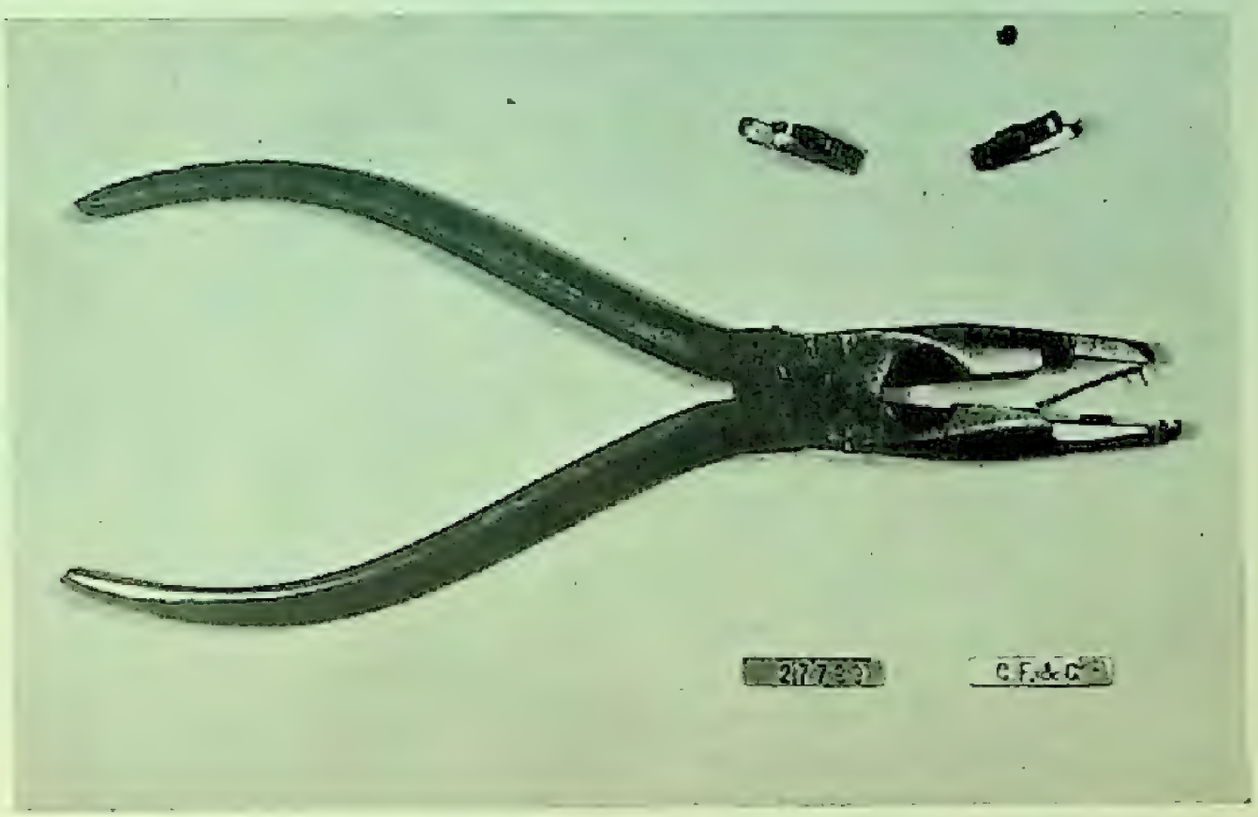


FIG. 9. Mackerel tags and tagging pliers. The strap tags shown at the top are clinched into the gill cover of the fish with the pliers. The pliers force the point of the tag through the gill cover, through the hole in the other end of the tag, and bend it over. The pliers are quite simple but must be very accurately made if they are to work properly. A tag is shown in the pliers, ready to apply. The internal tags, shown below, are inserted into the body cavity of the fish through a small slit made in its side. The internal tags are used for both sardines and mackerel.

enough along the edges. The operating capacity of the drum just described is probably about 5,000 tags. It works very nicely with 1,000 and 3,000 (the largest number we have put into it).

After smoothing, the tags irritate the fish much less and seem to stay on better, just how much better we can not say until more time has elapsed.

Another thing was done when it became evident that the strap tags were none too permanent; that was to experiment with the most enduring type of tag yet devised.

Internal tags or belly tags are flat pieces of celluloid or metal which are slipped into the body cavity of the fish through a tiny slit made in its side. If properly inserted, there is very little chance of

their being lost. This makes them suitable for tracing long migrations, but for tracing short movements they are not at all satisfactory. Being inside the fish, they are not readily noticed, hence we must use metal tags and depend on magnets for most of our recoveries. The magnets in use in California do not recover the tag until the fish heads and offal have been made into meal. The delay involved makes it impossible to learn what boat took the fish or where it was taken. All we can be certain of is that the place of capture was within 75 miles of port, since the mackerel and sardine boats never operate more than that distance from the cannery. At times there are many mackerel mixed with the cannery sardine catches, so we can expect recoveries even when the boats are not fishing for mackerel.

## Tagging Methods

The method of tagging mackerel has undergone many minor changes since it was first started. The present system is about as follows: The boat is anchored and live bait or ground-up fish is thrown into the water to chum up a school. While this is being done, an impounding net, about 12 feet across and 4 feet deep, is tied to the side or stern of the boat. If the fish are ravenous, or can be gotten into a frenzy of excitement by proper chumming, everyone fishes with a bamboo pole, 2 to 5 feet of line, 18 inches of wire leader, and a feather striker with a barbless hook. A mackerel hits the striker, is flipped into the impounding net and allowed to spit the hook out. If the job is done properly the fish will usually be rid of the hook while still in mid air, or within a second or two after landing. The commercial fishermen's way of cracking the whip will loosen the hook instantly, but this method can not be used on fish which must be released uninjured. When fishing slows down, part or all of the crew use bait on striker hooks which have lost their feathers. If the fish get still more particular, it is necessary to use a gut leader and an ordinary 3/0 or 4/0 hook which has had the barb flattened. Each fish has to be unhooked from this rig by hand—and it is hard on the hands. A hand line is the last resort; it is used only when the mackerel refuse to come to the surface. At Monterey and other points where the mackerel apparently do not school so readily, hand lines are used exclusively.

When fishing gets too slow or the impounding net becomes crowded, part of the crew stops fishing and starts the actual tagging operations. Preferably at least one man continues to chum and fish, and if the mackerel suddenly start to bite again everyone grabs a pole until the spurt is over.

Tagging operations can be efficiently carried out by crews of 2, 3 or 4 men. When four men are used, the work is arranged as follows: One man dips a fish out of the net and holds it in front of the measurer who lifts it out of the dip net onto the measuring board, calls out the length and lifts the edge of one gill cover. The tagger, using a special pair of pliers, slips the tag into position, clinches it shut, and then removes and reloads his pliers while the measurer is getting that fish overboard and grasping the next one. A fourth man keeps the records, noting tag number and length of fish.

When internal tags are used the process is very much the same for everyone except the tagger. This man uses a scalpel to make a tiny slit in the side of the fish, inserts the tag part way with his fingers and pushes it clear in with a pair of forceps.

Unlike some other fish, mackerel do not lie quietly and allow the routine to go along smoothly. They could give lessons to the proverbial greased pig and consequently the recovering of fumbles is all too common a part of any tagging trip. Two other pet stunts are knocking the tag out of the pliers and curving its body into a rigid arc. This last makes an accurate measurement impossible but does lift one gill cover and makes things easy for the tagger.

### Location of Tagging Operations

At the end of 1936, a total of 4051 mackerel had been tagged. The range of operations was from Monterey, California, to Magdalena Bay, Lower California—a distance of about 1000 miles. Of these fish, 737 were tagged at Monterey, 2113 in southern California between Pt. Dume and San Diego, 960 in Sebastian Viscaino Bay (half way down the coast of Lower California) and 241 in more southern waters.

### Recoveries

As mentioned above, 4051 mackerel had been tagged by the end of 1936. Of these, 209 had been recovered. This is a good return and shows promise for the future, but it is still much too soon to attempt to draw any conclusions regarding the movements of the fish.

### Location of Future Tagging Operations

From our present knowledge it appears that we should increase the intensity of tagging in the areas already worked rather than try out any new ones. The important regions are:

1. *Sebastian Viscaino Bay, Lower California.* There is no mackerel fishing done in this area and no chance of recovering any fish tagged there unless they move at least as far north as Ensenada or San Diego. A migration of this distance is bound to take time, hence permanence of the tag is of vital importance. For this reason, large numbers of internal tags should be used, at least until we are sure that our thoroughly smoothed strap tags are staying in place. Small mackerel abound in several places along the mainland shore of Viscaino Bay. These should be tagged almost exclusively with internal tags, as young fish are even more prone to lose strap tags than adults and will have to grow for a year at the very least before they become large enough to enter into the cannery catch in any numbers.

2. *San Quentin, Lower California.* This area is about half way between Viscaino Bay and San Diego. There are mackerel in the region and it would be advisable to tag some if a good opportunity presents itself, or if we have difficulty in getting enough fish farther south.

3. *Monterey, California.* This area is the farthest north that mackerel are taken in quantity. There is a good sized market fishery and some canning is done. The canneries are equipped with magnets.

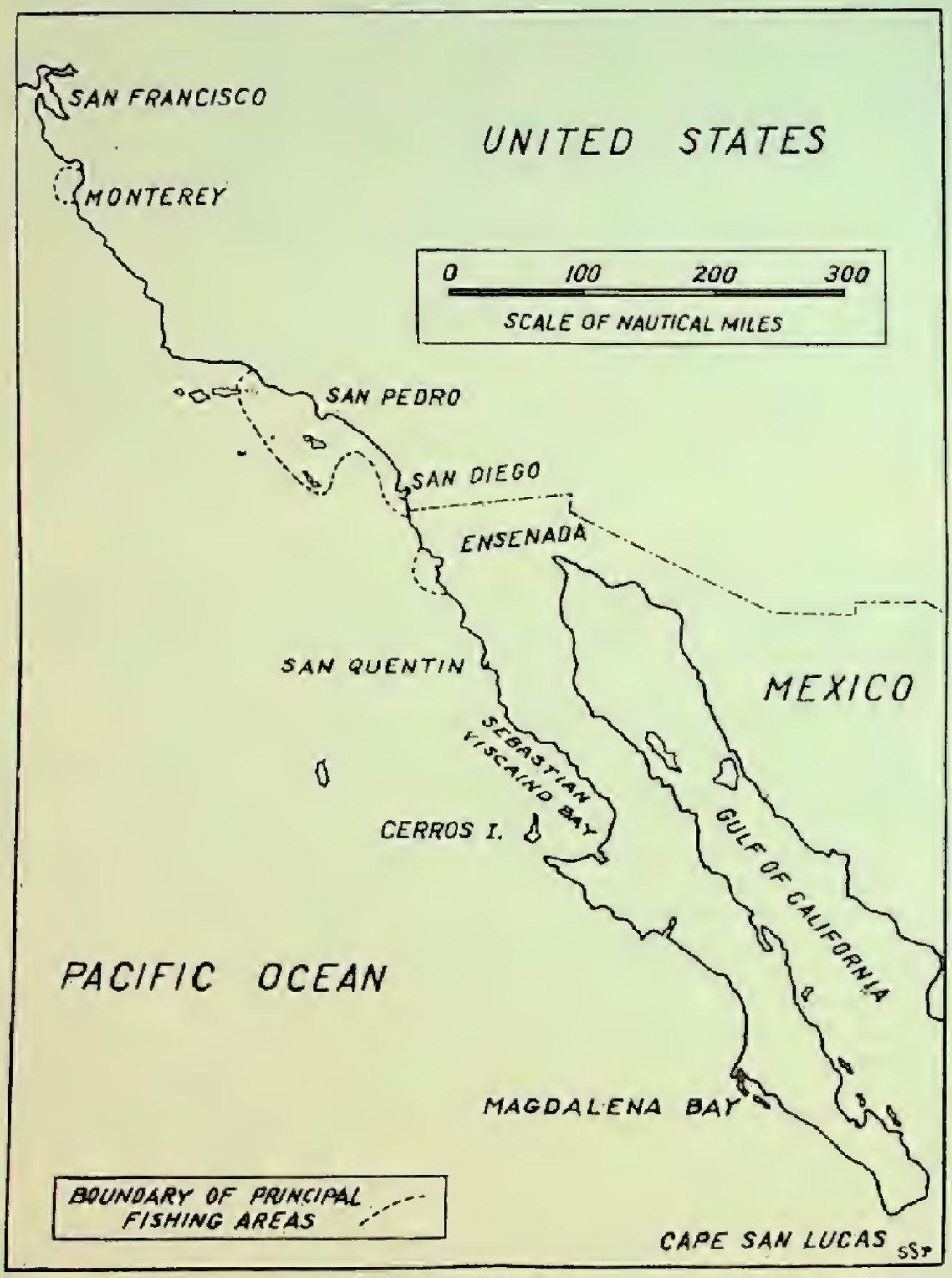


FIG. 10. Map showing the territory included in the mackerel tagging operations. Tagging has been done from Monterey in the north to Magdalena Bay in the south. Recoveries can be expected only in the areas of heavy fishing.

The important thing to learn at Monterey is whether or not the fish in that region move to and from southern California. Details about minor movements in the vicinity of Monterey are not important.

4. *Southern California.* This region is the one where most of the fish are taken and hence where most recoveries are to be expected. Tagging should be done to enable us to learn to what extent the fish move north to Monterey. The trip is a long one and internal tags would seem to be in order for a large part of the fish. Many strap tags should also be applied as it is only by their use that we will be able to learn what minor movements take place within this comparatively large area. Tagging, particularly strap tagging, should be scattered over as many places as possible. The fishing should be done in the open, a mile or more from shore when possible. The greater part of the population stays fairly well offshore and it is possible that by fishing in sheltered places we would get mackerel with well established habits, quite different from those of the great majority.

In conclusion it can be said that the mackerel tagging program has shown more than enough promise to warrant its continuance. It will be pushed with vigor and we can look forward to an increased knowledge of the habits of the mackerel and a better insight to their abundance.

# THE RELATION BETWEEN SURFACE WATER TEMPERATURE AND THE DISTRIBUTION OF SPAWN OF THE CALIFORNIA SARDINE

## Sardinops caerulea [1]

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*Division of Fish and Game*

It has been known for many years that changes in temperature have a profound effect on a large number of physiological processes such as the rate of metabolism, growth, and reproduction. Under constant temperature conditions, these processes proceed at a characteristic, uniform rate and a rise in temperature results in an acceleration of the rate.

The ascending curves of growth, reproduction, and metabolic processes in general of invertebrates and cold-blooded vertebrates, such as fishes, are subject to seasonal interruptions and proceed at a faster rate in summer than in winter. This has been interpreted as being due to several causes, the most important of which is the annual rise and fall in temperature. It is interesting to note that a rise of one degree Centigrade increases the rate of metabolism by roughly ten per cent, and a rise of ten degrees doubles the rate of metabolic processes.

Orton (1920) has shown that the breeding seasons of many animals lie within comparatively small limits of temperature, and has found that the Atlantic mackerel (*Scomber scomber*) begins to spawn at 12–13° C. He also states that "* * * a minimum breeding temperature would therefore appear to be a physiological constant for the species." There is then a temperature threshold below which metabolic activities are at so low a level that the gonads do not develop and spawning will not take place. This is presumably the case with the California sardine, where the lower limit of spawning lies in the neighborhood of 13° C. Two other fish for which a definite temperature-breeding correlation has been shown are the herring (Hjort, 1910) and the yellow perch (Lea, 1913). There are others too numerous to mention here.

Attempts have been made to find a correlation between spawning and salinities. Nilsson (1914) found in the case of the eggs of the Atlantic mackerel that "* * * the most important factor concerning the distribution is undoubtedly salinity * * * the low degree of salinity in the waters of the inner fjords at the same level accounts for the absence of mackerel eggs in this locality." The concensus of opinion, however, regarding salinities and breeding is summed up by Orton (1920) in his statement that "* * * investigations on the

[1] Submitted for publication, March, 1937.

breeding periods of animals have strengthened the view of the importance of an appropriate temperature and weakened that of the effect of *normal* changes in salinity in controlling breeding in marine animals in general." The observations by Clark (1934) tend to support this view; she found that the percentage of maturing eggs of the California sardine showed no correlation with salinities. Schmidt (1909) on the other hand believes that there is a sensitivity to salinity variations in the spawning habits of some fishes. This is represented in the extreme cases of the fresh-water eel (*Anguilla vulgaris*) which spawns in the ocean at a great distance from its ordinary habitat, and the various species of salmon which live in the ocean but ascend the streams to spawn. Although many obscure factors are here involved, it is probable that salinity plays an important part in this phenomenon. It seems more reasonable to assume that ordinary fishes, such as the sardine, are not greatly affected by the small variations in salinity which are ordinarily encountered throughout their spawning ranges. More work, however, needs to be done, and salinity analyses should be a part of the routine work of plankton hauls for eggs and larvae.

Although salmon and the fresh-water eel are not typical cases but rather represent extremes, they are nevertheless good illustrations of the fact that the distribution of a fish may be much wider than its spawning range, and that spawning does not necessarily take place throughout the entire range of the species. Recognition of this principle led Schmidt (1909) to make the statement that "* * * * the spawning region of a species is often much more restricted than its distribution in general," and that this restriction is determined by definite hydrographical conditions. This is found to be true of the California sardine in that spawning is largely restricted to the more southern part of its range.

## Analysis of the Sardine Data

It was found by Scofield (1934) and later confirmed by the writer that there exists a definite relationship between surface water temperatures and the distribution and abundance of sardine eggs, but an analysis of the data on which this relationship was based has not hitherto been published.

The California sardine (*Sardinops caerulea*) is found over a great area, from southern Alaska to Cape San Lucas, Lower California, but spawning is largely confined to the southern part of its range. The eggs are pelagic and spawning takes place near the surface. Scofield (1934) established that there is a region of maximum spawning which lies between Point Conception and San Diego and offshore for some one hundred miles. To the north as far as San Francisco intermittent spawnings were found inshore, but only in localities where the temperature was greater than 13° C. During the four years covered by his investigation (1929 to 1932), 1930 and especially 1931 were years of unusually high surface temperatures both north and south of Point Conception and only during those same two years were sardine eggs found inshore in northern waters. Even then the eggs were present in only relatively small numbers and in restricted and unpredictable localities. This led to the conclusion that in normal years temperature conditions were unfavorable for spawning inshore north of Point

Conception. Conditions in the warm California current are discussed below.

In 1936 two trips were made by the writer into Mexican waters along the coast of Lower California in an attempt to determine the extent of spawning and the season in which spawning occurred in this region. The results of these trips and several made previously show that the spawning season in more southern waters probably starts earlier than in those off the southern California coast. Spawning has been found in Lower California from the early part of February to the middle of July. The spawning in February, 1936, was fairly heavy, and it is felt that the season may begin in January or possibly in December. There are no indications at the present time that spawning begins before February in the waters off southern California. Although no attempt was made at quantitative estimates, it was apparent that there was a sizeable spawning in the Sebastian Viscaino Bay region and some localized spawnings were found as far south as Cape San Lucas. The importance of this southern spawning can not as yet be told.

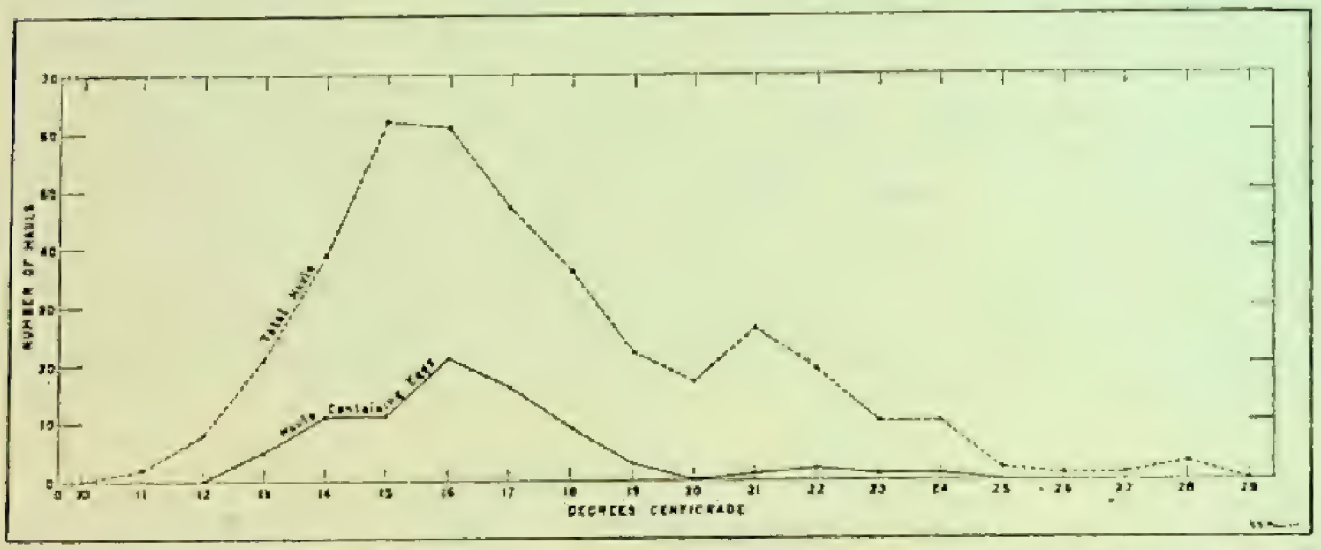


FIG. 11. Graph showing the total number of hauls made at each temperature and the number of hauls which contained sardine eggs.

The data for all hauls from California and Mexican waters, from the investigations by E. C. Scofield from 1929 to 1932 and by the writer during 1936, have been combined in figure 11, showing the total hauls made and the number of hauls which contained sardine eggs. These data show that:

1. No temperatures were encountered below 11° or above 28° C.
2. One-half of the hauls were made at temperatures between 15° and 18°.
3. No eggs were encountered below 13°.
4. The maximum number of hauls containing eggs was at 16°.
5. One-half of the hauls that contained eggs were made at temperatures between 15° and 18° C. We may conclude that this range represents the optimum temperature for sardine spawning.

In figure 12 the data for California and Mexico have been separated. Hauls made below Point Descanso (about half way between San Diego and Ensenada) were considered as being off Mexico, and those made above were considered as being off California. This division

affords a more reasonable boundary for the purpose at hand than the political line. Two facts are evident—temperatures in Mexican waters are higher than those in California, and it naturally follows that the main spawning takes place at a higher temperature in Mexico than in California.

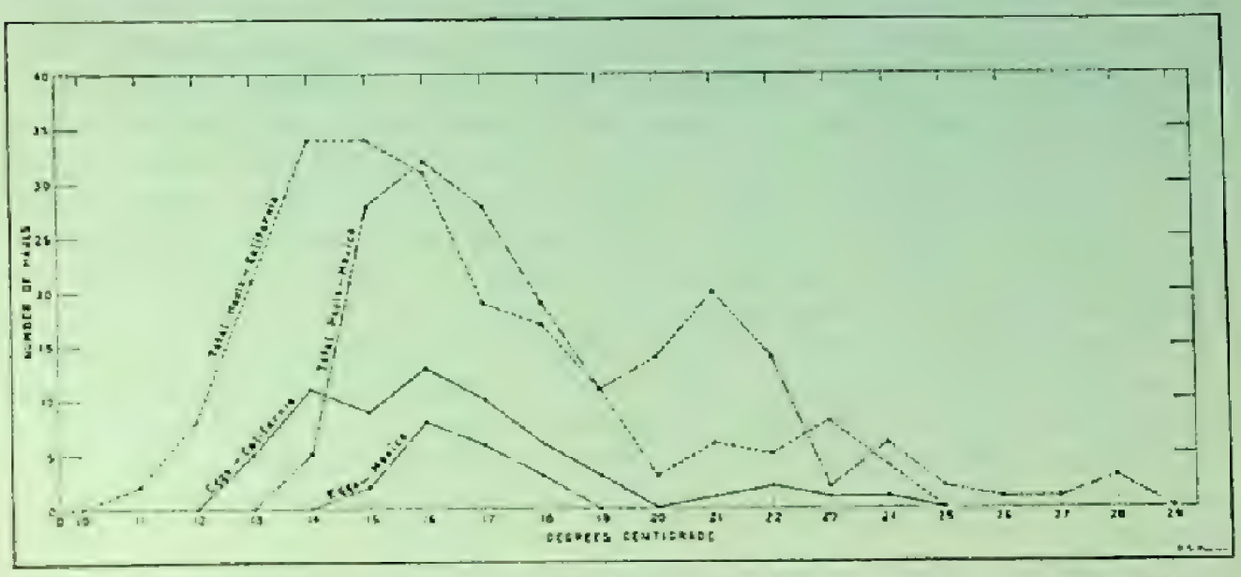

FIG. 12. Graph showing the relation between the total number of hauls made in California waters and in Mexico, and the number of hauls in those localities which contained sardine eggs.

Eggs taken in California at 21°, 22°, 23°, and 24° were all caught within the region of maximum spawning off the southern California coast during 1931, the year of unusually high surface temperatures.

Figure 13 is a graphic representation of the average monthly surface temperatures at four localities from 1926 to 1933: San Francisco (North Farallon Island), Monterey (at shore off Pacific Grove), Hueneme (pier), and San Diego (Scripps Institution of Oceanography

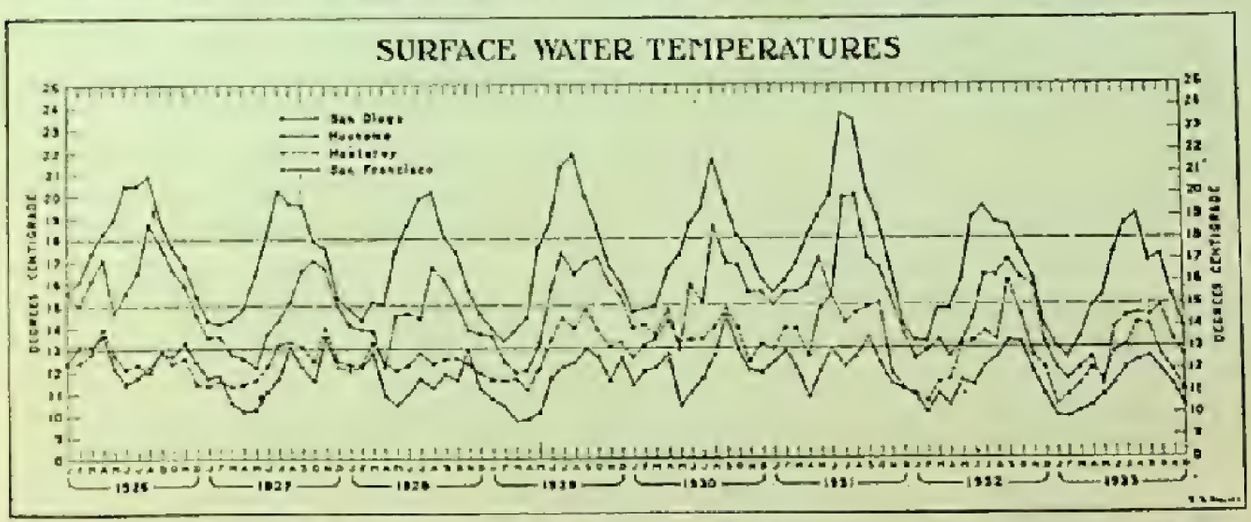


FIG. 13. Surface water temperatures at San Diego, Hueneme, Monterey and San Francisco, 1926–1933. The solid line at 13° represents the lowest temperature at which sardine eggs have been taken, most of the eggs have been taken between 15° and 18°, as represented by the two broken lines.

pier, La Jolla). These temperature records have been made available to us through the courtesy of the Scripps Institution of Oceanography. The line extending across the graph at 13° represents the lowest temperature at which sardine eggs have been taken, and the two broken

lines represent the upper and lower limits of the range in which 50 per cent of the hauls containing eggs were taken, or in other words the optimum range for sardine spawning.

This figure shows that the temperature off San Francisco seldom exceeded 13°, or the lower limit of spawning, and never extended into the optimum temperature range. Monterey is a little better in this respect: the temperatures were consistently a few degrees higher than at San Francisco. The characteristics of the curve for Hueneme indicate that this region (or regions which have similar temperatures) is the one most favorable for sardine spawning. This is in exact agreement with observed conditions. In the San Diego region the temperatures run, if anything, too high. This again is in agreement with our observations, as San Diego is approximately at the lower edge of the region of maximum spawning.

The surface temperatures along the west coast of Lower California are such that spawning may take place. In 1936 a fairly heavy spawning was found in the Viscaino Bay region and it is of great importance to establish whether or not this region contributes to the sardine population of the coast of California. Three main lines of study are here involved:

1. An investigation into surface current phenomena and the occurrence and distribution of sardine larvae and young fish to discover if the larvae from Mexico do or do not mingle with those from California.

2. Tagging experiments to show whether or not the sardines of Lower California and those of California constitute a single population and migrate from one region to the other.

3. A series of quantitative plankton investigations to determine the relative abundance of sardine eggs and larvae in the two regions.

The possibility has been suggested that there is an abundant spawning in the warm California Current which runs parallel to the coast of California and some distance offshore. This is based on the fact that surface temperatures in that current lie within the range favorable for sardine spawning. On the basis of temperature alone one would expect that spawning might take place in the California Current. This was found to be the case, but it is remarkable that the number of eggs was very much smaller in the region north of Point Conception as compared with that in more southerly waters. A very sharp dividing line is manifest in that eggs north of Point Conception were present in numbers not exceeding, at the most, a few hundreds, whereas south of that region identical hauls revealed thousands. The reasons for this phenomenon are not readily apparent, but this much is indicated—that factors will very possibly be found which, in spite of favorable temperature conditions, determine the scarcity of sardine eggs and larvae to the north.

The data for the California Current are incomplete and a program is under consideration which will, if carried through, establish whether or not the California Current is important as a spawning ground for the sardine. The same general problems are here involved as have been stated for the investigation on Lower California, and more information must be made available before a satisfactory answer may be found. Positive evidence, incomplete as it is, however, indicates that the spawning in the California Current north of Point Conception is of minor importance. There is no foundation in fact, as far as present

data show, for the assumption that an abundant spawning takes place in that region.

## Summary

1. There is a temperature threshold below which metabolic activities are at so low a level that the gonads do not develop and spawning will not take place.

2. There exists a definite relationship between surface water temperatures and the extent and abundance of sardine spawning.

3. The minimum temperature at which spawning will take place is approximately 13° C.

4. The optimum temperature is between 15° and 18°.

5. Spawning may not be expected inshore in the San Francisco region or farther north, with the possible exception of an occasional fortuitous spawning of very minor importance in years of unusually high surface temperatures.

6. Occasional inshore spawnings may take place at Monterey, more often than at San Francisco, but will not be frequent enough or large enough to make any material contribution to the general sardine population.

7. Temperature conditions in the California Current are favorable for sardine spawning but eggs and larvae have not been found in any numbers in this current north of Point Conception. The reason for this is not clear but it is indicated that other factors may be involved which determine this scarcity.

## LITERATURE CITED

Clark, Frances N.

1934. Maturity of the California sardine (*Sardina caerulea*), determined by ova diameter measurements. Calif. Div. Fish and Game, Fish Bull., no. 42, 49 pp.

Hjort, Johan

1910. Report on herring-investigations until January 1910. Cons. Perm. Int. Explor. Mer, Publ. Circ., no. 53, 174 pp.

Lea, Einar

1913. Further studies concerning the methods of calculating the growth of herrings. Cons. Perm. Int. Explor. Mer, Publ. Circ., no. 66, 35 pp.

Nilsson, David

1914. A contribution to the biology of the mackerel; investigations in Swedish waters. Cons. Perm. Int. Explor. Mer, Publ. Circ., no. 69, 61 pp.

Orton, J. H.

1920. Sea-temperature, breeding and distribution in marine animals. Mar. Biol. Assn., Journ., n.s., vol. 12, no. 2, pp. 339-366.

Scofield, Eugene C.

1934. Early life history of the California sardine (*Sardina caerulea*), with special reference to distribution of eggs and larvae. Calif. Div. Fish and Game, Fish Bull., no. 41, 48 pp.

Schmidt, Johs.

1909. The distribution of the pelagic fry and the spawning regions of the gadoids in the North Atlantic from Iceland to Spain, based chiefly on Danish investigations. Cons. Perm. Int. Explor. Mer, Rapp. Proc.-Verb., vol. 10, no. 4, 229 pp.

# PROGRESS REPORT OF TROUT FEEDING EXPERIMENTS, 1936[1]

*By* J. H. WALES AND RICHARD BLISS
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It has been the aim of the Mt. Shasta Experimental Trout Hatchery to run tests on various foods and to perfect feeding methods in an entirely practical manner. Large groups of fish are used and their care is the same as in the producing hatchery. This policy has been followed so that the results when found to be good can be put into immediate use.

The following were the principal objectives in the 1936 set of experiments: (1) to test the value of dehydrated beef meal as a trout food, and (2) to determine the effectiveness of feeding meals mixed with liver as compared to feeding the meals separately.

## Description of Experimental Fish and Their Care

The fish used were brook trout (*Salvelinus fontinalis*) from eggs shipped to Mt. Shasta from Colorado. They were from unselected fish. The eggs were 415 per ounce in size. About 24,000 eggs were placed in each of 14 baskets. Hatching was completed on January 25, 1936. On February 8, when the fish started to feed, 23,000 were put in each trough. All of the troughs were given identical care except for the differences in diet and in feeding methods. To prevent overcrowding, the fish were thinned down to 300 ounces per trough on May 25, and on July 8 were thinned to 400 ounces. Due to an epizootic of furunculosis and our inability to buy more meat meal from the manufacturers, the experimental diets were discontinued after August 1. The fish were kept, however, to ascertain their comparative resistance to the disease.

One hundred or more fingerlings in each trough were weighed at the start of feeding and at biweekly intervals thereafter. A record was kept of the weight of the food fed during the experiments. The losses in each trough were recorded. The water temperatures ranged between 40° and 56° F.

## Description of Foods

Beef liver and beef heart: These were fed while fresh. Cost of liver was 16c per lb. Cost of heart was 9c per lb.

Salmon egg meal: The cost of this was 7c per lb.

Dry skim milk: This was an insoluble feed grade and cost 5.1c per lb.

[1]This is the third report of experiments which are being conducted at the California Division of Fish and Game Experimental Trout Hatchery located at Mt. Shasta: submitted for publication, February, 1937. See also previous reports published in *California Fish and Game*: vol. 21, no. 2, pp. 110-124, 1935; vol. 22, no. 2, pp. 111-117 (figures on pp. 105-110), 1936.

Dehydrated beef meal: This was purchased in San Francisco at 3.5c per lb. At present this meal is not being manufactured in the west.

Salmon meal: This was purchased at 3.5c per lb.

Wheat middlings: The cost was 2c per lb.

### Preparation of Food and Feeding

Finely ground beef heart was fed to all the experimental groups for the first seven weeks. Then, when they averaged about 150 fish per ounce, the feeding of liver and meals was started. Groups 1, 3, 5 and 6 were fed the meals mixed with the liver in the same manner used in the last two years, *i. e.*, the desired amounts of finely ground liver, meals and water were thoroughly mixed by hand, then ground through a meat grinder. This mixture was allowed to stand for two hours or more and was then fed through the regulation perforated bottom dippers. Groups 2 and 4 were fed the same foods as 1 and 3 but the ingredients were presented to the fish in a different manner. The liver was fed through a perforated bottom dipper once a day (in this case the noon feed) and the meals were fed in the morning and afternoon. When fish are as small as 150 per ounce it is difficult to prepare the meals so that they can be fed alone without having them break up and be lost in the water. The writers had fair success making the combination of meals slightly moist and then stirring them until the particles had clumped together, remotely resembling cottage cheese. This could be scattered to the fish by shaking it through a screen bottom dipper or by throwing it with the hand. These clumps of particles or curds could be broken up by the fish very easily and the amount of pollution was kept at a minimum.

However, the efficiency of this method does not seem to be as great as in the usual method where the meals are mixed with the liver. With our grinder it was impossible to start feeding pellets until the fish were at a size of 25 per ounce. These pellets were made by moistening the meals as in the previous method, then grinding them through the plate with the smallest holes (in this case 5/64 inch). The resulting spaghetti-like strings were allowed to stand until they could be broken by hand into short lengths. These pellets were fed twice a day and straight liver once daily to groups 2 and 4. The results were excellent, growth was good, the cost was low, there was less pollution of the water, and the fish could be fed in this manner more quickly and easily than when the meals are mixed with the liver. The pellets often fall to the bottom of the trough too rapidly for the fish to catch them but they are picked up and very little is wasted. If the fish are in ponds, the greater depth of the water allows more time to catch the pellets before touching the bottom. All trout from about 25 per ounce (400 per pound) on up can be fed pellets, the size of which can be varied to suit the fish. Most of the usual fish foods can be made into pellets although some ingredients such as raw wheat middlings make the small pellets too sticky. Some experience is necessary in order to get the correct amount of moisture in the mixture to be formed into pellets. The larger the pellets, the more moisture they will stand without becoming sticky. There is a limit to the amount of liver which can be incorporated in

the smallest pellets. The writers' experience shows this level to be less than 20 per cent by weight as fed. In other words, when making pellets for fish between the sizes of 25 and 2 per ounce, it was necessary to mix 80 ounces of dry meals with 20 or less ounces of liver in order that the pellets do not become too sticky and thus fail to separate. A major difficulty in the production of pellet type trout food lies in the grinder. The writers feel that they have yet to use a good grinder for this purpose. A grinder suitable for liver may be and usually is far too weak for pellet manufacture. Some sort of large, powerful, direct drive assembly can probably be purchased. In addition to the grinder, various sorts of food mixers could be employed to prepare the food for grinding. However, this task can be done by hand without too much labor.

For the benefit of those who have not used pellets for fingerlings and adult trout the foregoing discussion might well be summarized.

1. Pellets may be composed of dry meals entirely or a combination of dry meals and fresh meat.

2. The size of the pellets may be varied by the use of different sized grinder plates.

3. The food to be made into pellets must be relatively dry. If meals alone are to be used they can be dampened but slightly, and if small pellets are to be made of a combination of meals and liver the amount of liver should not exceed 20 per cent by weight of pellets.

4. The larger the plate used the greater can be the amount of moisture in the food.

5. Pellets suitable for small fish (25-2 per ounce) can not incorporate enough fresh meat, so it is necessary to feed straight meat occasionally. Pellets suitable for adult trout, made with a half-inch plate, can incorporate enough fresh meat to be fed exclusively.

6. To make pellets one mixes the ingredients thoroughly and grinds them through the appropriate plate. The resulting spaghetti-like strands are then broken into short lengths and the food is ready to use.

In addition to this method of preparing the pellets we can recommend a feeding program as follows:

1. Finely ground heart for the first 4-8 weeks.

2. 50 per cent liver and 50 per cent meals by weight, mixed together and fed through a perforated dipper until the fish average 25 per ounce.

3. Pellets made of meals alone twice a day and liver fed through a perforated dipper once a day until fish are 2 per ounce.

4. From the time the fish are about 2 per ounce they may be fed pellets containing meals and approximately 20 per cent liver by weight as fed. The size of the plate used for manufacturing the pellets varies from 5/64-inch on up as the fish grow.

This procedure might seem to be too complicated and to require extra labor but this is not the case. In fact, one can feed in less time and with less labor by this method when equipped with the proper meal bins, mixing machine and grinder. The expense of installing the correct machinery is easily balanced by the lowered cost of food, ease of feeding and the smaller amount of pollution in the water.

## Mortality

The health of the fish was as good as could be expected until the furunculosis started. The loss was never more than the average for a producing hatchery. The best results of the six different groups were in the fish that were fed liver, salmon egg and meat meal mixed together. The mortality rates in all groups can be seen in the table.

It was thought that the addition of raw wheat middlings to a diet might be of interest as this practice is not uncommon. We have shown that the presence of the middlings is of no great importance although the mortality and cost were both relatively high.

Furunculosis was to be found in the eastern brook trout brood stock at Shasta and undoubtedly the experimental fish took it from them. The fish started to die from furunculosis on July 22 and by August 12 all groups had become infected. The greatest daily loss for the entire lot occurred on August 18, about seventeen days after the average beginning. The end of the epizootic occurred in all groups between September 11 and October 26. The average time for the disease to end occurred on September 23, or about eight weeks after the epizootic started. During this period approximately 92 per cent of the fish were killed by furunculosis and *Chloromyxum* in the kidneys. This latter disease became noticeable toward the end of the epizootic and caused an appreciable part of the deaths. The external symptoms of these two diseases are usually alike except when boils are present in furunculosis so it was impossible to tell just what percentages can be assigned to each disease. Nevertheless, it is certain that furunculosis was much more important than the *Chloromyxum*. The characteristics of the furunculosis were about average. The percentage with external boils was small. The fish which were badly affected with *Chloromyxum*, probably *C. truttae*, differed from those dying from furunculosis in the appearance of the kidneys which were considerably swollen and of a gray-red color.

The effect of diet upon the presence and severity of the diseases was very confusing. No clear-cut correlation could be seen. The fish that were fed with the diet (No. 1) of liver, salmon egg and meat meal had the lowest mortality before the epizootic began, and then suffered most from furunculosis. Each diet group was made up of two troughs, the lower trough receiving its water from the upper. One would expect to see some correlation between the two troughs of such a combination but this was not the case. The upper trough of group 4 showed the disease five days before the lower did, while the upper trough of group 6 showed the disease 16 days after the lower. The disease was more severe in the lower trough of group 4, whereas it was less severe in the lowers of groups 5 and 6. The lower trough of group 4 suffered much more than the lower in group 5. This lack of correlation persisted throughout the entire hatchery. The only positive thing we can say is that no conclusions can be drawn on the effect of diet on furunculosis. It is also evident that if we had not been using large groups of fish, with each group composed of two troughs, we might easily have come to erroneous conclusions or to conclusions which can not now be made.

One should not get the impression from the foregoing discussion that diet has no influence on the resistance of trout to furunculosis. On the contrary, it is probable that diet does play quite an important role. However, the diets used in these experiments were quite similar in respect to their basic ingredients, and for this reason the effect upon disease was about the same in all. The experiments were not designed to elucidate the effect of certain foods upon resistance to furunculosis. If experiments were undertaken to determine the elements most important in bringing about resistance, a simple basic diet would be fed to all groups and mineral, vitamin and probably other modifications made to certain groups. The number of fish used in each group should be as large as possible. Experiments of this sort should be undertaken by a number of investigators working under dissimilar conditions.

## Growth

Growth was reasonably good in all the groups. Differences might have become apparent if the tests could have been continued, but due to the outbreak of furunculosis our growth comparisons end at the first of August, less than six months after feeding began. The lack of variation in growth might be partially explained by the fact that we fed a relatively high percentage of liver in all diets. This liver percentage might tend to compensate for slight inequalities in the meals. We fed such a high liver percentage (55–58 per cent by weight, as fed) for entirely practical reasons. In one case where the liver and meals were mixed together and fed by dipper, 58 per cent of liver was necessary to give the proper consistency to prevent undue pollution of the water. In the case where the liver and meals were fed separately, 55 per cent by weight of the day's food made just enough liver for one feed. It would have been possible to reduce this quantity of liver if we had not been comparing two methods of feeding the same food.

We feel sure that meat meal, when it can be obtained, is an excellent trout food and can be placed in the same category as salmon egg and dry milk as excellent fresh meat substitutes.

## Cost

The only important point brought out by these experiments is that the cost of feeding trout fingerlings is less when the meals of a liver-meal diet are fed in pellet form than when the liver is mixed with the meals and the combination fed through a perforated bottom dipper. This seems to be due to two facts: First, that when the meals were fed in pellet form less liver was fed and the cost reduced accordingly, and, second, that the consumption of the meals in pellet form is more efficient. There is likely to be considerable waste of meals through separation into the water when the meals are fed mixed with the liver.

## Summary

1. Eastern brook trout fingerlings were used in feeding experiments to determine the value of dehydrated beef meal as a trout food, and to compare the efficiency of feeding meals mixed with liver and meals in pellet form fed separate from the liver.

2. It was determined that dehydrated beef meal, when it can be purchased, is a valuable trout food, comparing favorably with salmon egg meal and dry skim milk.

3. It was found that meals can be prepared in pellet form and fed to trout which are larger than 25 per ounce. When the meals are thus fed separately from liver it is more efficient, easier and cleaner than when the meals are mixed with the liver and fed through a perforated bottom dipper in the usual manner. Especially is this true when the fish are kept in raceways and ponds.

TABLE 1

DESCRIPTION OF EXPERIMENTAL GROUPS, 1936

| Group | Species | Number of fish at start | Percentages of foods are by weight as fed | Method of feeding |
|---|---|---|---|---|
| 1 | Brook trout | 46,000 | Liver 58% plus salmon egg 21% plus meat meal 21% | Liver and meals mixed. |
| 2 | Brook trout | 46,000 | Liver 55% plus salmon egg 22.5% plus meat meal 22.5% | Liver once a day; meal pellets twice a day. |
| 3 | Brook trout | 46,000 | Liver 58% plus dry milk 21% plus meat meal 21% | Liver and meals mixed. |
| 4 | Brook trout | 46,000 | Liver 55% plus dry milk 22.5% plus meat meal 22.5% | Liver once a day; meal pellets twice a day. |
| 5 | Brook trout | 46,000 | Liver 58% plus salmon meal 21% plus meat meal 21% | Liver and meals mixed. |
| 6 | Brook trout | 46,000 | Liver 58% plus salmon egg 14% plus meat meal 14% plus wheat middlings 14% | Liver and meals mixed. |

TABLE 2

SUMMARY OF RESULTS OF 1936 TROUT FEEDING EXPERIMENTS

| Group | Pounds of food as fed to produce a pound of trout | Pounds of food dry weight to produce a pound of trout | Cost of food to produce a pound of trout | Cost per 1,000 fish | Number of fish per ounce at end of experiment | Pounds of fish produced | Total mortality of fingerlings, Feb. 13-July 31 | Percentage of mortality of fingerlings | Percentage of mortality of fry |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.53 | 1.37 | $0 32 | $2 09 | 9.6 | 152 | 1,892 | 3.80 | 1.40 |
| 2 | 2.40 | 1.39 | 29 | 1 78 | 10.2 | 150 | 2,474 | 5.02 | 1.65 |
| 3 | 3.05 | 1.64 | 38 | 1 62 | 14.5 | 126 | 2,181 | 4.77 | 1.45 |
| 4 | 2.32 | 1.34 | 27 | 1 77 | 9.6 | 156 | 2,506 | 5.40 | 1.70 |
| 5 | 2.79 | 1.50 | 33 | 1 64 | 12.7 | 138 | 2,432 | 4.93 | 1.75 |
| 6 | 2.98 | 1.90 | 37 | 1 84 | 12.3 | 129 | 3,064 | 6.16 | 2.05 |

# SESTONOSIS, A GILL IRRITATION IN TROUT [1]

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The disease reported in this paper is caused by certain kinds of foreign matter in the water, which irritate the gills, and is not brought about by a specific organism. It is felt that this disease is more widespread than previously believed. So far as is known young fingerlings are the only trout to be affected and some strains are more susceptible than others.

The majority of the fish hatched and reared to planting size at the Lake Almanor Hatchery, where the disease is prevalent, are rainbow trout from eggs collected at various stations on streams tributary to the lake. These fish develop a serious gill disease each year about two weeks after feeding has started. Brook trout fingerlings are also troubled by the disease, but not the brown trout or salmon. The external symptoms are not unlike those in other forms of gill disease or in Octomitiasis. The fish lose their appetites and become so emaciated and weak that they lose their equilibrium and are washed down against the end screen. Losses from this disease reach figures high enough to make it one of the principal causes of trout mortality in the State. After much study, it was concluded that no single organism was responsible, nor was food pollution to be suspected. Nearly every dead and dying fingerling had a relatively large mass of foreign matter and mucus lying on the base of the tongue and fastened to the gill arches. This was apparently making it difficult for the fish to eat and to breathe. In addition, the gill filaments were badly swollen and could not properly absorb oxygen.

The Lake Almanor Hatchery takes its water from Clear Creek which is composed of the water from several springs. These springs flow from a lava bluff into a meadow where they form a broad shallow stream heavily grown with various flowering aquatic plants and algae. This portion of the stream is about one-half mile long and the hatchery intake is situated at the lower end before the stream assumes a narrower, swifter character. As the name of the creek implies, the water is apparently free from foreign matter during the major part of the year. However, with a plankton net one can collect 0.36 cc. of plankton per 100 gallons of the water as it enters the hatchery troughs. The plankton is composed of a variety of diatoms and other small algal forms, together with a small number of protozoa and bacteria.

The following experiments were conducted to test the theory of gill irritation and weak strains of fish: We hatched and reared rainbow from the Klamath River, Big Creek and Lake Almanor strains at

[1] Submitted for publication, February, 1937.

both the Almanor and Mt. Shasta hatcheries. These strains were represented by 25,000 to 50,000 fingerlings. These numbers we felt were sufficiently large to avoid error. In addition to these large scale experiments we held two smaller lots of Almanor rainbow at the Lake Almanor Hatchery. Each of these contained 5,000 fish and were kept in comparable portions of two troughs. One of these groups of 5,000 fish was supplied with the regular hatchery water and the other group was supplied with water taken directly from one of the springs before it entered the large shallow algae-filled portion of the stream mentioned previously. The pure spring water was supplied from a domestic water line. This supply of water contained but a small quantity of foreign matter. All of the groups were given similar care. The food was 100 per cent beef liver. The dead fish were counted daily at Mt. Shasta and in the small scale groups at Lake Almanor. The experiments were continued until well past the period of gill disease.

The results are as follows: The three strains at Mt. Shasta showed less difference in growth and health than those at the Almanor Hatchery, however, the Klamath River fish were the healthiest and grew fastest while the Almanor fish suffered the most from the gill disease and consequently grew slowest. The Big Creek fish suffered slightly less than the Almanor fish. At the end of the experiment at Mt. Shasta the weights and mortalities were as follows:

| | *No. of fish per oz. at end of experiment* | *Percentage of mortality* |
|---|---|---|
| Almanor fish | 49 | 22 |
| Big Creek fish | 40 | 21 |
| Klamath River fish | 35 | 7 |

The disease appeared in the fingerlings at Mt. Shasta approximately two weeks after feeding commenced and was similar in other respects to its manifestation at Lake Almanor. The amount of detritus in the Mt. Shasta water was high but contained more decaying vegetable matter and less diatoms, algae, bacteria, and protozoa.

At the Lake Almanor Hatchery the results were more striking. The Klamath River fish suffered very little from the disease whereas the Almanor and Big Creek fish were seriously affected. The three different strains hatched at such widely separated dates, and the data on weights and mortality were so fragmentary that it is impossible to give definite figures on the large groups. However, the growth was most rapid in the Klamath strain and these fish did not contract the gill disease. The Big Creek and Almanor rainbow grew slowly and suffered considerable losses.

The two small groups of Almanor rainbow, one of which was supplied with regular hatchery water and the other with the pure spring water had remarkably different growth and mortality rates.

| | *No. of fish per oz. at end of experiment* | *Percentage of mortality* |
|---|---|---|
| 5,000 Almanor rainbow trout kept in regular (polluted) hatchery water | 84 | 61 |
| 5,000 Almanor rainbow trout kept in pure spring water | 65 | 8 |

As the above figures show, the gill disease appeared only in the fish kept in the polluted water and growth was correspondingly retarded.

There seems to be little doubt that certain kinds of foreign matter in hatchery waters are more injurious than others. Inorganic sediments are usually not as harmful as organic material, and living organisms such as diatoms, filamentous algae, bacteria and protozoa are by far the most harmful.

It seems quite evident from these experiments that certain wild strains of trout are more easily affected by irritants in the water than others. Just why this should be so is not clear but the difference in resistance might have been brought about by natural selection in the native waters of these particular strains of rainbow. The Klamath River strain is native to a water which is highly charged with planktonic algae and it seems probable that the fish have become resistant to this form of gill irritation. The Almanor and Big Creek strains are native to waters comparatively free from pollution of this type.

In conclusion we can say that two factors are active in this particular gill disease. In the first place certain hatchery waters are polluted by diatoms, other small algal forms, bacteria and protozoa. This foreign matter is very injurious, mechanically, to the gills of certain strains of trout. In the second place certain strains of trout are more easily injured than others by the above-mentioned foreign matter. Therefore when a susceptible strain of trout is reared in this type of polluted water the gills become irritated to such an extent that heavy losses are suffered within a few weeks after feeding starts.

The solution to the problem at the Almanor Hatchery would be an intake pipe line which would bring water from one of the springs at the head of the stream rather than from the lower end of the shallow algae-filled section. A filter, if properly constructed, might serve the purpose but would be much more troublesome.

Occasionally it might be possible to rear the susceptible strains of trout in hatcheries having pure water and the hardy strains in polluted water.

We propose the name Sestonosis for this type of gill disease. The term *Seston* designates the mixture of living and nonliving bodies which float in water. The ending *-osis* indicates a disease.

# THE RELATIVE SUSCEPTIBILITY OF VARIOUS STRAINS OF TROUT TO FURUNCULOSIS[1]

*By* J. H. WALES AND WILLIAM BERRIAN
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In several outbreaks of furunculosis in California it appeared that all of the exposed species of trout fingerlings were not equally susceptible to the disease. The question then arose, whether the various strains of the bacteria might differ in their virulence for any one species of trout. In an attempt to answer this question we subjected brook trout, brown trout, silver salmon, and two strains of steelhead trout fingerlings to a single strain of furunculosis and noted the ensuing mortality.

The following fish were placed together in a suitably large rectangular pond in July, 1936. The water temperature varied from 43° to 70° F., with an average of about 58°. The food was 100 per cent beef heart.

| *Species* | *No.* | *No. fish per oz.* | *Source of eggs* |
|---|---|---|---|
| Brook trout | 2,500 | 6.0 | Mt. Whitney Hatchery, Calif. |
| Brown trout | 2,500 | 6.4 | Mt. Shasta Hatchery, Calif. |
| Steelhead trout | 2,500 | 12.0 | Scott Creek Egg Station, Calif. |
| Silver Salmon | 2,500 | 6.0 | Scott Creek Egg Station, Calif. |
| Steelhead trout* | 11,000 | 60.0 | Klamath River Egg Station, Calif. |

* These were placed in a circular pond.

On July 20 and on August 4, all of the fish were given furunculosis bacteria in the food. These bacteria had been in culture media for several weeks and were presumably weakened to a point where it was impossible for the disease to infect the fish. Therefore, on August 14 another strain of furunculosis was placed in the food. This culture was made from the epizootic in the Mt. Shasta experimental eastern brook trout.[2] On August 22, eight days after the last introduction of the bacteria the silver salmon, brown trout and brook trout showed the disease. On August 29 the steelhead contracted the disease, fifteen days after its introduction. The steelhead in the circular pond did not show symptoms of furunculosis until September 16, 34 days after the last introduction of the bacteria. At this time they weighed 15 per ounce. The course of the disease in all species ran much the same. Its progress was slow for a few days, then there was a sudden flare-up for five to ten days, followed by an equally sudden decrease and a long period when losses were slight. The entire

[1] Submitted for publication, February, 1937.
[2] See "Progress report of trout feeding experiments, 1936," pp. 138-143, of this issue.

course of the disease ran approximately 70 days, during which time the percentage losses, presumably from furunculosis, were as follows:

| | |
|---|---|
| Brook trout | 98% |
| Silver salmon | 92% |
| Scott Creek steelhead | 82% |
| Klamath steelhead | 64% |
| Brown trout | 50% |

Fin-rot was present to some extent in all the groups. The degree to which the species were affected by this disease is shown in the following list, the steelhead suffering most:

1. Klamath steelhead
2. Brook trout
3. Scott Creek steelhead
4. Brown trout
5. Silver salmon

The bearing which fin-rot may have had on furunculosis is not clear, but it is more than probable that it predisposes the fish to furunculosis, either by producing lesions through which furunculosis bacteria can enter the fish, or by generally weakening their resistance. Both of these factors may be partially responsible for the apparent relationship. It is quite obvious that cases of fin-rot should be cured by appropriate treatments as early as possible in order to reduce the chances of contracting furunculosis.

It is interesting to note the location of furunculosis boils in the various species. The following list gives the average or usual position only:

| | |
|---|---|
| Brook trout | near dorsal fin |
| Brown trout | on belly |
| Klamath steelhead | near dorsal fin and on belly |
| Scott Creek steelhead | near dorsal fin and on sides |
| Silver salmon | on top of head |

In conclusion, we can say that all of the species of trout and salmon used in this experiment were susceptible to one strain of furunculosis which came originally from brook trout fingerlings. They were not equally susceptible, but further tests would be necessary to determine whether this was an inherent difference or due to age, fin-rot or some other predisposing influence. However, we have good reason to believe that if one species in a hatchery contracts the disease other species may also become infected.

# NOTES ON THE FOOD OF TROUT OF YOSEMITE NATIONAL PARK

*By* H. JOHN RAYNER [1]

In the interests of the many nature lovers and sportsmen who annually visit Yosemite National Park, and to further the knowledge of the food of trout, the following results of a study of the contents of the stomachs of trout from many regions of the park are submitted.[2]

Specimens were collected for the most part with the aid of artificial dry flies at altitudes ranging from 3,000 to 10,900 feet, in streams, rivers and lakes during the summer of 1936. Mr. Hamilton MacCaughey supplied most of the trout not taken by the author. A few trout were sent in by various fishermen. The writer was stationed on the floor of Yosemite Valley and at Tuolumne Meadows. The environs of these two places supplied all of the trout examined except for six golden trout from a small unnamed lake just outside of the park boundary on the eastern slope of Mt. Conness.

The species of trout concerned in the study were the rainbow (*Salmo irideus*), cut-throat or black-spotted (*Salmo henshawi*), eastern brook or speckled (*Salvelinus fontinalis*), golden (*Salmo aqua-bonita*) and the Loch Leven or brown trout (*Salmo levenensis*).

A student of the ecology of fishes must consider food as an important factor in life conditions. The trout is a fish of diverse food habits, and this fact is borne out by the results of studies made of trout stomach contents in many regions of the United States and of the world. Since the fauna of waters and the food of trout inhabiting those waters may well be known by an examination of the stomach contents of the trout, this method has formed the basis of this paper.

The Class Insecta (insects) includes some of the finest kinds of trout food. The Orders of Trichoptera (caddis flies, caddis worms, case or stick worms, or periwinkles), Plecoptera (salmon or stone flies), Ephemeroptera (mayflies), Neuroptera (hellgrammites, alder, orl and fish flies), and Diptera (true flies, of the group known as midges) are most important in the diet of trout, and form, in general, the bulk of the food consumed of nutritive value. For illustrations and descriptions of the commoner forms mentioned here, see the references cited in the bibliography.

The food of trout may be divided into that which is terrestrial in origin and that of aquatic origin. Food of terrestrial origin may include beetles, ants, bees and wasps, leafhoppers, grasshoppers, true flies, true bugs (Hemiptera), and the adults of some aquatic forms which have

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emerged from the water and later fallen back. Food of aquatic origin may comprise the larval, nymphal or pupal forms of stone flies, caddis flies, mayflies, orl flies and midges, among other things.

The surface food is important only during the spring and summer months, and to complete a study of this sort, the winter food should be known. The data here given present a picture of the food taken at a given date and do not consider the food for the remainder of the year. Where the winter temperatures drop to near the freezing point, studies have shown that trout take little or no food. For example, in some hatcheries where low temperatures exist during the winter months, trout eat very little.

Many of the insects found in the stomachs were tried as lures for trout. Of these, the nymphs or adults of stone flies (Plecoptera) were by far the most attractive. The nymphs may be found by turning over large and small rocks in streams or in trash such as may collect in an eddy. The adults may be taken from vegetation on the stream and river banks, or they may be found emerging at dusk or shortly thereafter. With the aid of a light they may be found on the emergent rocks in the water or on the rocks and vegetation of the bank. Where other baits failed entirely, the stone flies were found to be successful as either floating or sunken lures in swift or quiet waters. The larger species, of one to one and one-half inches in length, were the most attractive to trout.

In the various streams and lakes as a whole, no one type of food was found to be dominant, but in a given area, the writer often noted a single group to be of primary importance. At the lower altitudes (3,500 to 4,000 feet), in streams and rivers, net-winged midges (true flies) and caddis flies were predominant. At higher altitudes (7,000 feet), in the streams, surface food of all kinds, particularly beetles, was of most importance, and caddis flies were again numerous. In the streams at 8,000 to 10,500 feet, stone flies were of greatest importance and again the caddis flies were high in number. Ants were present in varying numbers in nearly all the stomachs from streams. A seasonal study of these streams at different altitudes might reveal different results. Altitude may govern temperature and this factor may therefore determine the times of emergence of many aquatic and terrestrial insects.

Fish in any given lake were found to take much the same food, but this may vary as the depth changes, as streams enter, and as the vegetation at the water's edge changes. In lakes the food tended to become more homogeneous than in streams and rivers; it consisted largely of midges (Chironomidae: a family of the true flies, whose larvae are often called "bloodworms") and water mites (Hydrachnidae: minute animals, closely related to insects).

The reader may wonder if the food of this region differs from that of other areas where studies of similar nature have been made. In the lakes no scuds were in evidence, and one other member of the Crustacea was present in only one lake. Observations made at Hot Creek, California, by Paul R. Needham, proved scuds to be an important article of diet. Chancey Juday found Crustacea to be dominant in some Colorado lakes. In the higher lakes of the Colorado-Wyoming district, J. W. Scott found Crustacea to be important, and Dimick and

Mote have shown that "fresh-water shrimps (scuds) are important items in the diet of Oregon trout in lakes * * *." Midges have been reported (Paul R. Needham) as important in the lakes of the Sierra Nevada, and this is verified in the results obtained by the writer.

Altitude, bank and shore vegetation, type of bottom, stream or lake, season, and the availability and kinds of food present, largely determine the food taken.

Tables 1 to 6 are concerned with food of trout in lakes. In table 1 it is shown that there was little variation in the kinds of food taken by various individual trout in Upper Fletcher Lake at the time of the study, i. e., only certain representatives of any one food group are present. In no other area studied was there such a uniformity in so many food groups, even though this body of water is similar to many of the higher lakes of the region. A marked paucity of other forms is thus indicated.

In table 2 it is shown that aquatic true flies are of great importance. Almost without exception, the food was of aquatic forms. The diet of the golden trout in this lake differs from that of the same species in Upper Fletcher Lake; the factors governing this difference may be availability and amount of food.

In table 3 is given the food consumed by a single golden trout. All foods taken by this trout are forms that have an aquatic existence.

TABLE 1

Foods Consumed by 14 Golden Trout from Upper Fletcher Lake, Elevation, 10,400 feet.
Fish taken August 25, 1936; average length, 9 inches; maximum, 13 inches; minimum, 6.8 inches.

| *Class of food* | *No. found in all stomachs* | *Average percentage in stomachs by estimated volume* |
|---|---|---|
| Caddis flies (one species) | 20 | 10 |
| True bugs (two species) | 3 | 2 |
| Beetles (two species) | 68 | 23 |
| Mayflies | 2 | Less than 1 |
| True flies (midges alone) | 190 | 39 |
| Water mites | 42 | 7 |
| Leafhoppers (one species) | 20 | 6 |
| Ants and wasps | 45 | 12 |

TABLE 2

Foods Consumed by Six Golden Trout from a Small Unnamed Lake on Eastern Slope of Mt. Conness, Elevation, 10,300 Feet.
Fish taken August 6, 1936; average length, 6 inches.

| *Class of food* | *No. found in all stomachs* | *Average estimated percentage in all stomachs* |
|---|---|---|
| True flies (midges) | 280 | 90 |
| Caddis flies | 13 | 10 |
| Aphid | 1 | Less than 0.1 of 1% |

TABLE 3

Food of One Golden Trout from Lake Nelson, near Elizabeth Lake.
Fish taken August 6, 1936; length, 16 inches.

| *Class of food* | *No. found* | *Estimated percentage* |
|---|---|---|
| Water mites | 14 | 90 |
| Mayflies | 2 | 5 |
| Orl flies | 1 | 5 |

All of the food found in trout from Bernice Lake (table 4) was of aquatic forms except in one instance, where the trout contained a meadow mouse. These data differ greatly from those obtained at Upper Fletcher Lake, which is just over a mountain pass and approximately four miles away, where the food covered a wide range of groups. Of greatest importance are the aquatic true flies.

In table 5 is summarized the food of four eastern brook trout taken in Helen Lake. Here again, aquatic foods were dominant. In these stomachs was found a quantity of Crustacea (Copepoda) which were the only members of this group found during the summer in the stomachs examined. They were, for the most part, well digested and impossible to count.

In table 6 are listed the foods eaten by four eastern brook trout caught in May Lake. One of the trout had nothing in the stomach, but the remainder of the alimentary canal had in it a quantity of unrecognizable material. This trout was the only one of 103 examined which had an empty stomach. The three other trout had eaten aquatic foods. Two of the three had larger pieces of rock in their stomachs than any other trout examined.

TABLE 4

Foods Consumed by Eleven Eastern Brook Trout from
Bernice Lake, Elevation, 10,200 Feet.
Fish taken August 10, 1936; average length, 12 inches (uniform).

| *Class of food* | *No. found in all stomachs* | *Average percentage in all stomachs by estimated volume* |
|---|---|---|
| True flies (midges) | 282 | 75 |
| Water mites | 126 | 10 |
| Orl flies | 4 | 7 |
| Caddis flies (larvae) | 2 | Less than 1 |
| Miscellaneous (mouse) | 1 | 7 |
| Mollusk (small clam) | 4 | Less than 1 |

TABLE 5

Foods Consumed by Four Eastern Brook Trout from Helen Lake,
Elevation, 10,900 Feet.
Fish taken August 14, 1936; average length, 5 inches.

| *Class of food* | *No. found in all stomachs* | *Average percentage in all stomachs by estimated volume* |
|---|---|---|
| True flies (midges) | 158 | 61 |
| Crustacea | --- | 37 |
| Caddis flies (larvae) | 4 | Less than 1 |
| Wasp | 1 | 1 |
| Water beetle | 1 | 1 |

TABLE 6

Foods Consumed by Four Eastern Brook Trout from May Lake, Elevation, 9,300 Feet. Fish taken September 4 and 5, 1936; average length, 13 inches.

| *Class of food* | *No. found in all stomachs* | *Average percentage in all stomachs by estimated volume* |
|---|---|---|
| True flies (midges) | 97 | 65 |
| Mollusk (small clams) | 5 | 10 |
| Orl flies | 25 | 25 |

The following tables, 7 to 13, summarize the food contents of trout taken from several creeks and rivers at altitudes from 3,000 to 10,500 feet. A great variety of food forms are represented.

TABLE 7

Foods Consumed by Seventeen Rainbow Trout from the Merced River, Near the Lower Entrance to the Valley, at Arch Rock, Elevation 3,000 to 4,000 Feet. Fish taken June 10 to 17, 1936; average length, 8 inches; maximum, 12 inches; minimum, 6 inches.

| *Class of food* | *No. found in all stomachs* | *Average percentage in all stomachs by estimated volume* |
|---|---|---|
| Caddis flies | 59 | 20 |
| True flies (net-winged midges) | 44 | 24 |
| Mayflies | 71 | 18 |
| Stone flies | 59 | 15 |
| Beetles | 45 | 13 |
| True bugs | 15 | 3 |
| Ants, bees and wasps | 9 | 1 |
| Miscellaneous | 14 | 5 |

TABLE 8

Food of Ten Eastern Brook Trout from Yosemite Creek, Elevation, 7,000 Feet. Fish taken July 6, 1936; average length, 6 inches.

| *Class of food* | *No. found in all stomachs* | *Average percentage in all stomachs by estimated volume* |
|---|---|---|
| Caddis flies | 67 | 28 |
| True flies | 9 | 2 |
| Mayflies | 1 | Less than 1 |
| Stone flies | 14 | 5 |
| Beetles | 87 | 45 |
| True bugs | 12 | 11 |
| Wasps, bees and ants | 39 | 6 |
| Miscellaneous (1 large orl fly) | 1 | 2.5 |

TABLE 9

Food of Seven Rainbow Trout from Illilouette Creek,
Elevation, 7,000 Feet.
Fish taken July 16, 1936; average length, 6 inches.

| *Class of food* | *No. found in all stomachs* | *Average percentage in all stomachs by estimated volume* |
|---|---|---|
| Caddis flies | 31 | 30 |
| True flies | 4 | 2 |
| Mayflies | 8 | 3 |
| Stone flies | 5 | 7 |
| Beetles | 23 | 40 |
| True bugs | 4 | 4 |
| Wasps, bees and ants | 7 | 3 |
| Miscellaneous | 19 | 10 |

TABLE 10

Food of Ten Rainbow Trout from Bishop Creek, Elevation, 7,000 Feet.
Fish taken July 24, 1936; average length, 7 inches.

| *Class of food* | *No. found in all stomachs* | *Average percentage in all stomachs by estimated volume* |
|---|---|---|
| Caddis flies | 55 | 10 |
| True flies | 4 | 6 |
| Mayflies | 7 | 2 |
| Stone flies | 3 | 2 |
| Beetles | 18 | 30 |
| True bugs | 8 | 5 |
| Wasps, bees and ants | 13 | 3 |
| Miscellaneous (mostly nematodes; the remainder large uniques such as grasshoppers, orl flies and dragon-fly larvae) | 75 | 42 |

TABLE 11

Food of Ten Cut-throat Trout from the Headwaters of
Dana Fork of Tuolumne River, Elevation,
10,000 to 10,500 Feet.
Fish taken July 28, 1936; average length, 7 inches.

| *Class of food* | *No. found in all stomachs* | *Average percentage in all stomachs by estimated volume* |
|---|---|---|
| Caddis flies | 55 | 18 |
| True flies | 24 | 4 |
| Mayflies | 4 | Less than 1 |
| Stone flies | 60 | 69 |
| Beetles | 12 | 3 |
| True bugs | -- | -- |
| Wasps, bees and ants | 82 | 6 |
| Miscellaneous (leafhopper) | 1 | Less than 1 |

TABLE 12

Food of Five Loch Leven Trout from the Dana Fork of Tuolumne River, Elevation, 8,500 to 9,500 Feet.
Fish taken August 15 and 20, 1936; average length, 8 inches.

| *Class of food* | *No. found in all stomachs* | *Average percentage in all stomachs by estimated volume* |
|---|---|---|
| Caddis flies | 8 | 11 |
| True flies | -- | -- |
| Mayflies | 6 | 22 |
| Stone flies | 18 | 34 |
| Beetles | -- | -- |
| True bugs | -- | -- |
| Wasps, bees and ants | 28 | 32 |
| Miscellaneous (leafhopper) | 1 | Less than 1 |

TABLE 13

Food of One Eastern Brook, One Loch Leven and One Rainbow Trout from Dana Fork of Tuolumne River, Elevation, 8,900 Feet.
Fish taken August 28, 1936; lengths: eastern brook, 6 inches; Loch Leven, 6 inches; rainbow, 8 inches. All trout caught within one-half hour in a one-hundred yard stretch of stream. Stream bottom and current flow similar in the three places where the trout were caught.

| *Class of food* | *Brook Trout* | *Loch Leven* | *Rainbow* | *Average percentage in all stomachs* |
|---|---|---|---|---|
| Caddis flies | | | | 15 |
| pupae | 1 | | | |
| larvae | 3 | 2 | 1 | |
| adults | | | 1 | |
| True flies | | | | Less than 1 |
| black fly larvae | 1 | | | |
| midge larvae | | | 1 | |
| Mayflies (nymphs) | 2 | | 9 | 11 |
| Stoneflies | | | | 18 |
| nymphs | 1 | | 2 | |
| adults | | 2 | | |
| Ants | 12 | 8 | 7 | 46 |
| Miscellaneous | | | | 10 |
| scale insect | 1 | | | |
| butterfly larva | | 1 | | |

The different species of trout, the stomach contents of which are shown in table 13, show no marked difference in diet, at least no more than that exhibited by individuals of the same species.

A 20-inch Loch Leven trout, weighing 3 pounds and 10 ounces, was taken from the Lyell Fork of the Tuolumne River, at an elevation of 8,600 feet on September 5, 1936. This trout had two mice in the stomach, one of which was partly digested, the other recently captured. The last caught mouse had a body length of 4 inches and the tail was an additional 2 inches. The stomach was distended and the feet of the mouse last caught protruded into the oral cavity.

The writer believes altitude to be a very important factor in the food taken by the various species of trout in Yosemite National Park even though it seems indirect in its effect. This is borne out by many observations on streams, though it is not to be considered of primary importance. That the fish examined might have disgorged their stomach

contents is possible, and an error might result in this way. On the other hand, Dimick and Mote in Oregon could find no differences in the amounts or kinds of food organisms found in stomachs of fish netted or caught on a hook.

Though this paper may suffice as a matter of general interest, it is by no means conclusive, and further studies of food of fishes are urged for more complete and detailed data of use in stream and lake management problems.

## BIBLIOGRAPHY

Dimick, R. E., and Mote, D. G.
1934. A preliminary survey of the food of Oregon trout. Oregon State Agric. College, Agric. Exp. Sta., Sta. Bull., no. 323.

Juday, Chancey
1907. A study of Twin Lakes, Colorado, with especial consideration of the food of trouts. U. S. Bur. Fish., Bull., vol. 26, doc. 616, pp. 147-178.

Needham, J. G., and Needham, Paul R.
1935. Guide to the study of fresh-water biology; 3rd ed.

Needham, Paul R.
1934. Notes on the food of trout. Calif. Fish and Game, vol. 20, pp. 119-127.
1935. Stream survey work in California. Pacific Sportsman, vol. 15, no. 6, pp. 4-5.

Rayner, H. J.
1935. Insects as trout food. B. S. Thesis (manuscript) Calif. Univ., Div. Entom. Parasit.

Scott, J. W.
1930. Our present knowledge of trout food in the Rocky Mountain region. Colorado-Wyoming Acad. Sci., Journ., vol. 1, no. 2, p. 25.

Snyder, John O.
1933. California trout. Calif. Fish and Game, vol. 19, pp. 81-112.

Ward, Henry B., and Whipple, George C.
1918. Fresh-water biology; 1st ed. N. Y., John Wiley & Sons; 1111 pp.

# WEIGHT LOSS IN BARRACUDA DURING PREPARATION FOR MARKET[1]

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The California barracuda, *Sphyraena argentea,* is one of the most highly esteemed fishes in the southern California fresh fish trade, as well as being an important game species. Of the present laws governing the barracuda fishery in California, one forbids the sale of individuals weighing less than three pounds in the round (California Fish and Game Code, Sec. 732, 1935–1937). When fish are cleaned at sea, it is difficult to determine after landing whether a relatively small fish weighed as much as three pounds when caught. In view of the amount of barracuda landed dressed and for convenience, it has become the custom at San Pedro to allow one-half pound for cleaning loss. In other words, a fish weighing less than two and one-half pounds dressed has been considered undersized. Occasionally, fishermen bring in small fish not only eviscerated but also with the head removed, obviously attempting to evade the legal weight limit by making it impossible for round weight to be determined. It is customary among fresh fish dealers to sell barracuda with the heads on, as the fish look more attractive, but if fish are scarce headless individuals can be sold.

The purpose of this study was to determine the loss in weight when an average three-pound barracuda is dressed, in order to aid law enforcement officers in deciding the legality of fish delivered with viscera removed or with both viscera and head removed. As will be pointed out later, a size limit based on length would be far superior to the present weight limit. However, as long as existing regulations stand, this study may be of some assistance to those charged with enforcing them.

From October, 1935, through June, 1936, samples of barracuda were obtained from time to time when fresh fish were available. Some samples were undersized fish taken from fishermen, others were legal sized fish purchased at cost from fresh fish dealers. Each fish was weighed in the round and its total length measured. The fish was then eviscerated and weighed, its head removed, and the weight taken again, thus obtaining a series of three weights for each fish.

In all, 309 fish were measured, cleaned, and weighed. From these data the percentage loss due to eviscerating and the loss resulting from eviscerating and beheading were determined for each fish.

Due to a marked increase in cleaning loss during the summer or spawning season, it was necessary to divide the data into two parts, (1) spring and summer and (2) fall and winter, and treat each group separately. From an inspection of the data and a consideration

[1] Submitted for publication, March, 1937.

of Walford's discussion of the barracuda spawning season,[2] all fish caught from April 16 to August 31 were considered as belonging in the first group, whereas those caught from September 1 to April 15 were placed in the "fall and winter" group. Such division is of necessity only arbitrary, as the weights change gradually throughout

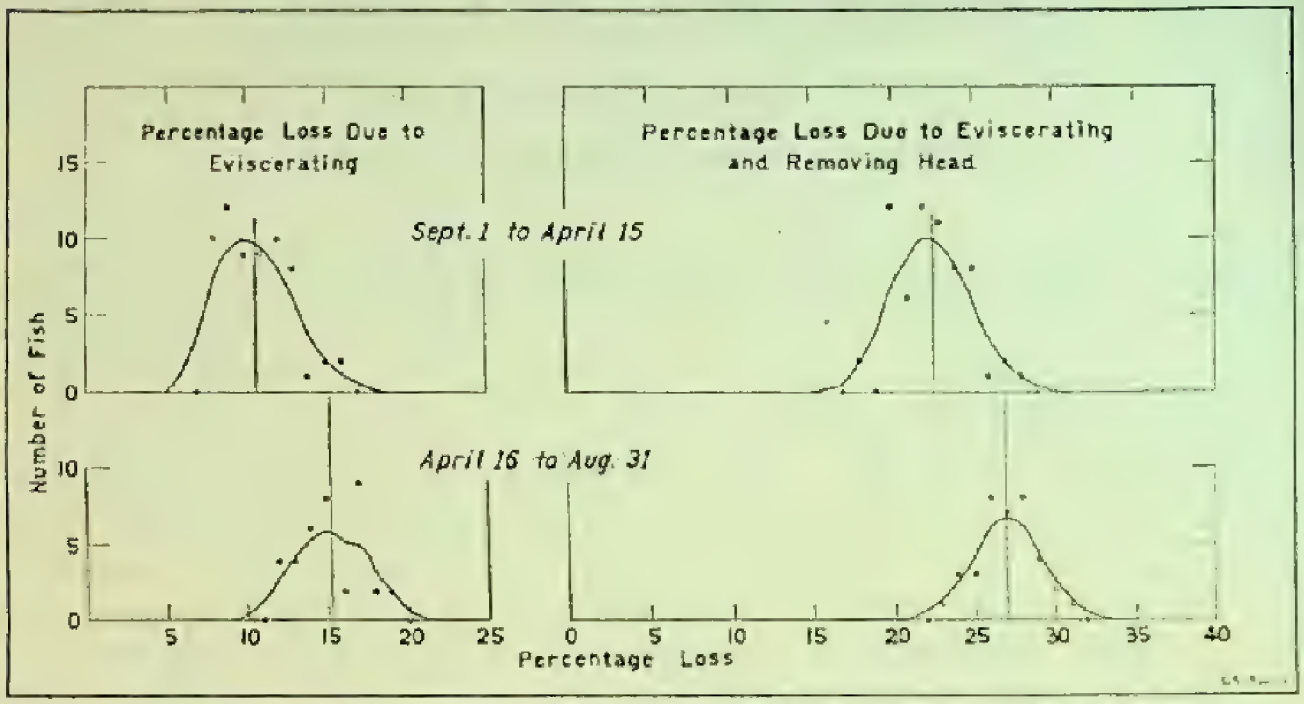
Percentage Loss Due to Eviscerating
Percentage Loss Due to Eviscerating and Removing Head
Sept. 1 to April 15
April 16 to Aug. 31
Number of Fish
Percentage Loss

FIG. 14. Four frequency curves showing percentage loss by seasons for barracuda between 2.50 and 3.49 pounds, inclusive. The original data, indicated by the open circles, were smoothed twice by a moving average of three to show trends. Vertical lines represent the averages.

the year, but some dividing lines must be drawn to show the seasonal variations and these have proven to be the most satisfactory.

Figure 14 shows four frequency curves, two of percentage losses due to eviscerating and two of percentage losses due to eviscerating and removing the head, for all fish between 2.5 and 3.49 pounds, inclusive. The original data, indicated by the open circles, were smoothed twice by a moving average of three to show the trend. The modes and averages are considerably higher in summer than in winter, as is to be expected from the large quantity of reproductive products removed with cleaning during the summer months. Figure 15 shows the increase in cleaning loss as the fish become larger, as well as the greater loss during the spawning season in comparison to the loss during fall and winter months. As barracuda mature before they enter the commercial fishery and spawn each year of their lives thereafter, all the fish affected by size regulations are subject to seasonal changes in weight.

Table 1 shows the average percentage loss calculated by adding the individual percentage losses for all fish between 2.5 and 3.49 pounds, inclusive, and dividing the sum by the number of individuals concerned.

[2] Walford, Lionel A. The California barracuda (*Sphyraena argentea*). Calif. Div. Fish and Game, Fish Bull., no. 37, p. 16.

TABLE 1

Average percentage loss for all fish between 2.5 and 3.49 lbs., inclusive

| | *Percentage loss due to eviscerating* | *Percentage loss due to eviscerating and removing head* |
|---|---|---|
| Spring and summer (April 16-August 31)__ | 15.22 | 26.97 |
| Fall and winter (September 1-April 15)____ | 10.75 | 22.52 |

If arbitrary weights are set for eviscerated fish and for eviscerated fish with head removed, below which fish are considered to be undersized, the question arises as to whether one year around limit should be made or whether two limits be made—one for the spring and summer and the other for the fall and winter. If the allowance is set high, equal to the average loss during the spawning season, the fall and winter fish will suffer a hardship by passing as legal size when they are considerably below three pounds when caught. This would defeat the conservation principle of the present law. On the other hand, if the allowance is low, equal to the average weight loss in the fall and winter, the fishermen would be penalized during the more important summer fishing season, as many fish weighing three pounds when caught would fall below the cleaning allowance after being dressed. Therefore, setting a single limit seems inadvisable. The chief objection to enforcing two limits, one for the spring and summer and the other for fall and winter, is that as two sets of two weights each are involved,

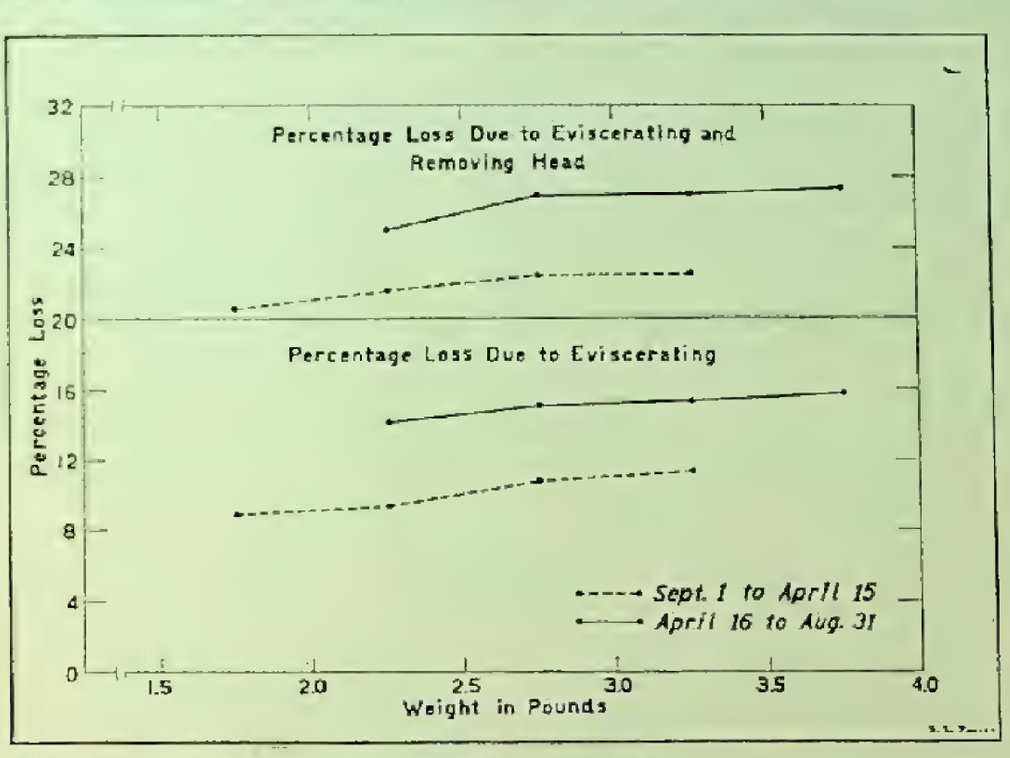


FIG. 15. Barracuda cleaning loss by size and by season. To illustrate the increase in cleaning loss as the fish become larger, the data were divided into half-pound groups.

they may be confused. However, it seems less objectionable to have two size limits on a seasonal basis rather than one all-year limit.

A definite fraction of a pound must be assigned for the average loss due to eviscerating and another for average loss due to eviscerating and beheading a three-pound fish. The averages given in table 1

are ideal, but it is obvious that odd decimal fractions and percentages can not be read off the scales used by fishermen and fish dealers. Table 2 shows the loss in pounds, by seasons, computed by converting the percentages given in table 1 to pounds in terms of loss to a three-pound round fish, and reducing the results to the nearest round numbers which may be read conveniently on the average scales.

TABLE 2

Average loss for all fish between 2.5 and 3.49 lbs., inclusive

| | *Loss due to eviscerating* | *Loss due to eviscerating and removing head* |
|---|---|---|
| Spring and summer (April 16-August 31) | ½ lb. | ¾ lb. |
| Fall and winter (September 1-April 15) | ⅓ lb. | ½ lb. |

Considering the weights given in table 2, it is recommended that all barracuda be classed as undersized which fall below the weights given in table 3.

TABLE 3

Weight of legal-size barracuda

| | *Round* | *Eviscerated* | *Eviscerated and head removed* |
|---|---|---|---|
| Spring and summer (April 16-August 31) | 3 lbs. | 2⅓ lbs. | 2¼ lbs. |
| Fall and winter (September 1-April 15) | 3 lbs. | 2⅔ lbs. | 2½ lbs. |

The above suggestions are made merely to aid in the enforcement of the present law. However, the law could be greatly improved by placing barracuda on a length limit. Few fishermen carry scales with them. Moreover, it is quite difficult to weigh a live barracuda accurately, especially on a rolling boat. On the other hand, these fish could be easily measured and thus many undersized individuals would be returned to the water alive. It is therefore strongly recommended that the present minimum size limit be changed from three pounds in weight to 28 inches in total length. This would mean no actual change in the minimum size limit of the fish, as a three-pound barracuda is approximately 28 inches long.

# HAS THE CLOSED AREA INCREASED THE PISMO CLAM POPULATION?[1]

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To further the conservation of the Pismo clam (*Tivela stultorum*) the California Division of Fish and Game has for a number of years carried on a study of the clam population on Pismo Beach. The study consists essentially of making comparable counts from year to year of the numbers of this intensively sought mollusk. In an analysis of the 1936 census one fact stands out above all others—that is the much better survival of clams on the protected part of the beach than on the portion open to digging.

The southern or most remote part of the beach was set aside as a clam refuge (District 18A) in 1929. This was done in the hope that a breeding population could be established in this area to help repopulate the entire beach. In addition if the area proved successful it might be possible at some time in the future to open the protected area and close some other portion of the beach, alternating different parts of the beach as conditions justified.

What then is the situation in the closed area after 7 years of protection? The answer is that there are definitely more mature clams on this part of the beach than there were in 1929. The increase is due to two factors, a series of unusually good sets of young clams and the added protection given these clams. Beginning with 1929 there have been four good sets of small clams on Pismo Beach. Most of the clams resulting from the first three of these good sets, laid down in 1929, 1930 and 1931, have reached the legal size of 5 inches in greatest diameter. In the closed area these year-classes have succeeded in producing a goodly proportion of legal-sized clams and in building up a fair spawning reserve. This increase in the number of legal clams in the closed section is illustrated in figure 16, which shows the yearly percentage that the legal clams form of the total population within the intertidal zone of the closed area. From 1929 to 1933, clams of 5 inches or more comprise not more than 2 per cent of all the clams. An increase began in 1934 and by 1936 legal-sized clams made up 22 per cent of the total clam population in the area.

The increase in large clams in the closed area is of real significance when compared with conditions in the area where diggers operate. In the intertidal zone of the open beach, legal clams have been exceedingly scarce over the same period, 1929-1936. At the time of the last census, November, 1936, legal-sized clams comprised but 8/10 of 1 per cent of the clam population of this area. This paucity of large clams

[1] Submitted for publication, December, 1936.

is due to intensive digging. Not only are the clams removed as fast as they reach 5 inches, but undersized clams are taken by some diggers in spite of constant patrol on the beach.

This augmentation in the numbers of large clams in that portion of Pismo Beach set aside as a clam refuge shows quite clearly that such a program of protection, rigidly enforced, can build up, within the protected area, a much depleted clam population. As yet we have

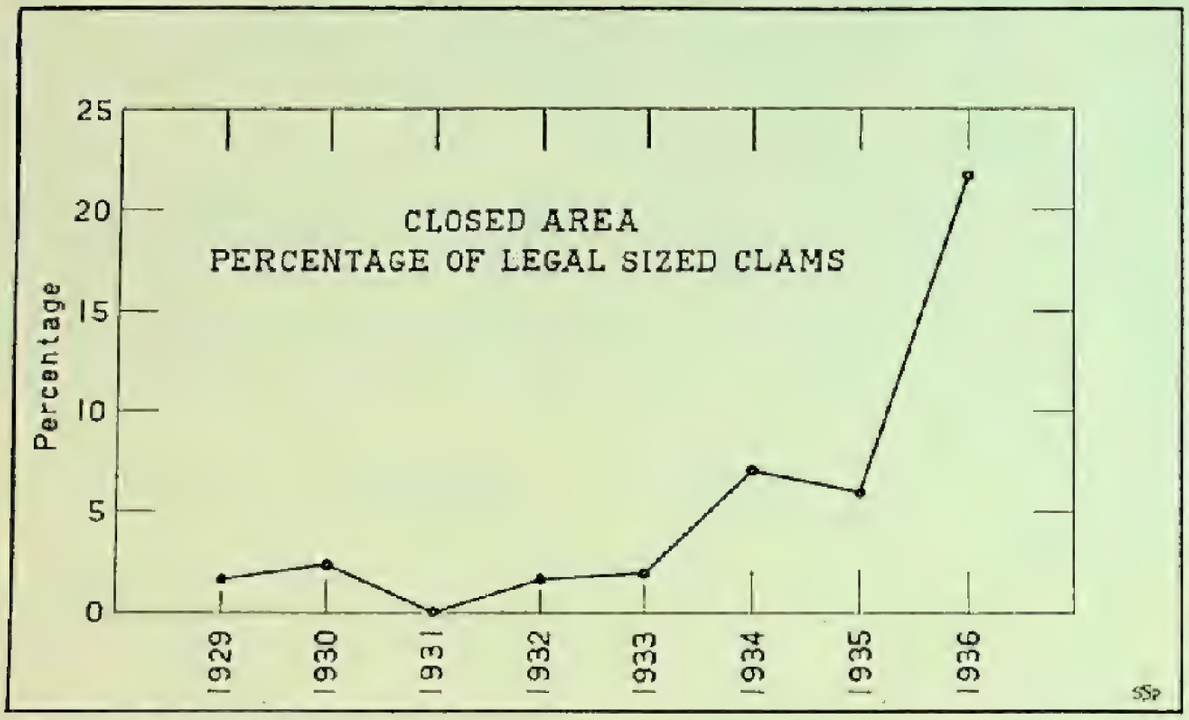


Fig. 16. Proportion of legal sized clams to all clams in the intertidal zone of the closed area of Pismo Beach (District 18A).

no positive evidence that the larger number of spawners has brought about an increase in the number of young clams produced each year along the entire beach. The data do hint, however, that the improvement in the sets during the past four years may have been somewhat influenced by this factor. The continued absence of large clams on the open beach shows, on the other hand, that a legal size and bag limit are not sufficient to do more than maintain the population of Pismo clams at its present relatively low level.

# REPORT ON THE CALIFORNIA OYSTER INDUSTRY FOR 1936[1]

*By* PAUL BONNOT
*Bureau of Commercial Fisheries*
*California Division of Fish and Game*

California oyster growing, at present, falls into two categories. In Humboldt Bay the effort is to establish the artificial culture of the native oyster (*Ostrea lurida*), using as a base the already existing natural beds. In some of the other bays which do not contain natural growths of natives, Japanese seed oysters (*Ostrea gigas*) are imported and planted. In our research program, more time is being spent on the culture of the natives as it is imperative for a successful development of this phase of the industry, that a comprehensive biological background be established. The Japanese oyster is very hardy and so far the technical work in connection with it has consisted, for the most part, of an inspection of the incoming shipments and the designation of suitable areas which seem to possess the necessary environmental conditions conducive to rapid growth, desirable shape and sanitary excellence.

## Native Oysters—Humboldt Bay

Although there are many purely biological problems to be solved in connection with the native oyster, for the time being it has seemed of more importance to devote the time exclusively to commercial aspects of oyster growing and to collect and endeavor to interpret biological data having an immediate and direct bearing on the problems of the growers. We must endeavor to create a fishery with biological knowledge based on other species and other geographical localities. As each bay seems to have its own combinations of environmental conditions, the work of other biologists can be applied only by the adoption of methods, altered when necessary, to fit local conditions, and the use of their deductions and conclusions as indicators. In this respect the work of A. E. Hopkins with the native oyster in Puget Sound has been of great assistance.

The 1936 oyster season at Humboldt Bay was an unqualified success. The artificial collectors of the commercial growers took a heavy set of native oysters and biological data were successfully obtained in satisfactory quantity. At the beginning of the season, the outlook was not very encouraging as the set of the previous season (1935) was very poor; the commercial collectors were put in at the wrong time, taking a very small set or none at all; and the scientific information collected was insufficient as a basis for making pertinent deductions. Early in May, 1936, a raid by sting rays all but eliminated

[1] Submitted for publication, March, 1937.

the natives on one of the most populous of the artificial beds. Because of these conditions only one company made up a quantity of artificial collectors.

As previously indicated the present work is an effort to create a fishery, rather than the investigation of one already established. It

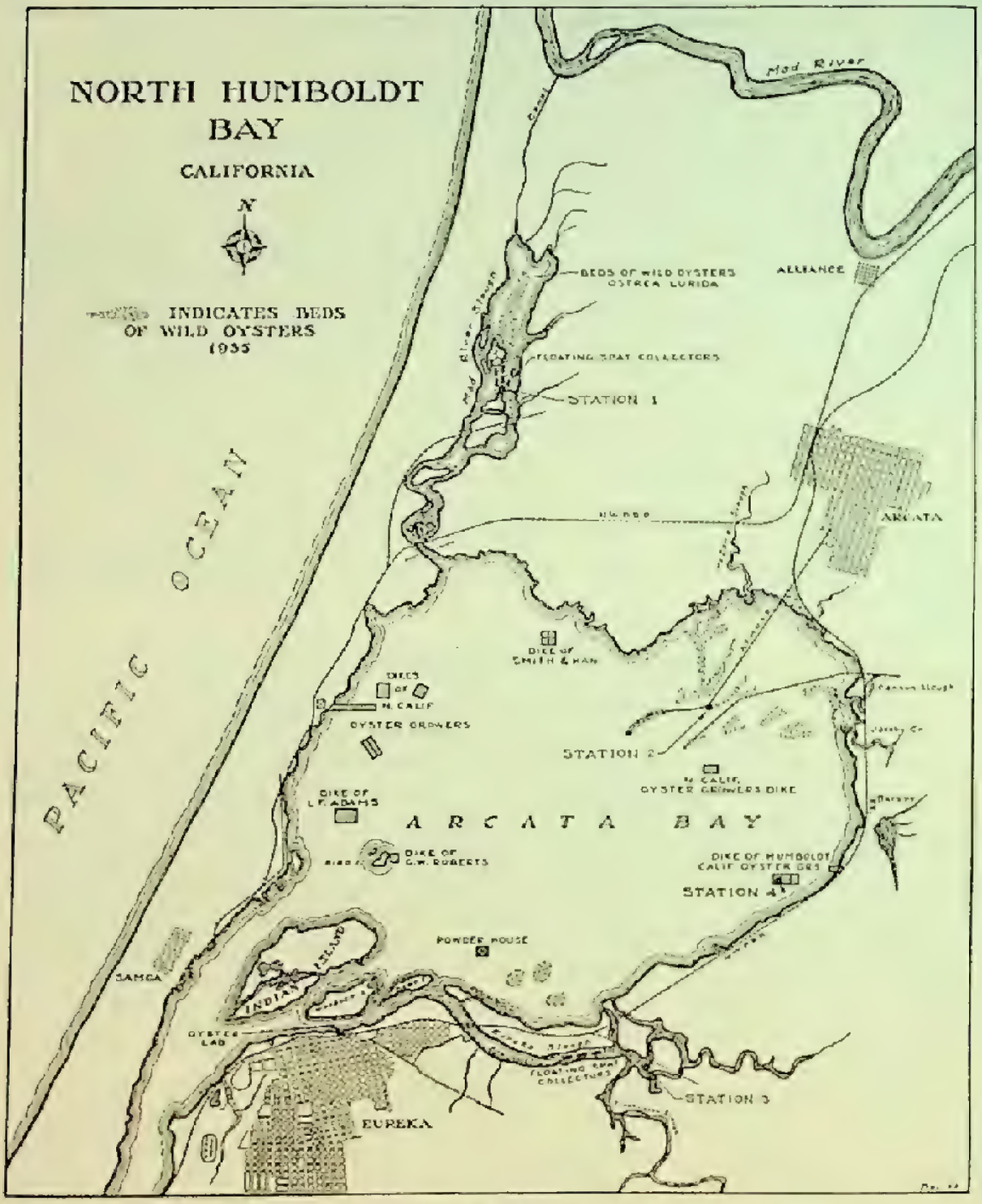


FIG. 17. Map of north Humboldt Bay, showing oyster beds.

is obvious, therefore, that the oyster industry is not at present able to support the very essential biological program. Believing in the future of the fishery, the Division of Fish and Game for several years has carried on the necessary research with the assistance of other interested agencies. The Humboldt County supervisors have con-

structed and maintained the oyster laboratory at Eureka and the various growers have willingly experimented with such suggestions as have been made to them. During the 1936 season, J. B. Johnson of the Bureau of Patrol was detailed as laboratory assistant.

The research work was conducted in the same manner as during the previous season; the same field stations and collecting units were maintained, with two minor changes.[2] The bags of shell, used to collect the setting larvae, were considered to contain 150 shells in 1935, whereas in 1936 they were rated as 100 shells. The water temperatures for 1935 were obtained in a dike at station 4, whereas in 1936 they were taken in the channel of Mad River Slough near station 1. The shell bags were put out and taken up at biweekly intervals, as before, and water samples to be tested for salinity and pH were taken at the various stations at each change of the shell bags. Oysters were collected at approximately weekly intervals, opened in the laboratory and studied to determine the degree of maturity.

In working up the shell bags, the shell was taken out from the top of the bag in lots of 25, and the spat on the inside smooth surface carefully counted. An average of three lots of 25 each was taken, added to the actual counts, and the total thus obtained multiplied by 2.36 to arrive at the total spat on 100 shells. Hopkins (unpublished manuscript) has found that the spat on the inside surface of the shell represents 35 per cent of the total number, which explains the last operation. The final total was divided by seven to obtain a daily average and the resulting figure used as a point in the set curve.

An innovation in spat collectors was introduced during the present season by the Humboldt California Oyster Growers. Thin pieces of plywood made up into sections of five slats and originally designed to cover vegetable crates were obtained from the barrel factory at Arcata. Four of the covers were tacked to a $\frac{3}{4}$-inch strip of redwood and the whole dipped in the usual mixture of sand and cement. Five or six such units were stacked, one on top of the other, and the battery thus formed placed in the dike at the proper time. The dikes hold sufficient water to keep them covered at all times. Each individual slat measures $2\frac{1}{4} \times 22$ inches. Reference to figure 18 will make clear the make-up of the units and the manner in which they are stacked together. Aside from the fact that these collectors took a very large set, several very interesting results developed in connection with their use. The most striking phenomenon was that they caught spat on both the top and bottom surfaces, with the exception of the top of the upper slat and the lower surface of the bottom slat. Oyster larvae normally swim inverted and set on the under side of a horizontal surface, and the explanation of the present departure seems to be that as the rough, cemented surfaces are only $\frac{3}{4}$ of an inch apart, the friction caused by the current makes a turbulent condition between the layers. The larvae would be rolled over and over and those that were finally deposited on an upper surface would set there. The batteries of collectors do not show an even distribution of set throughout. The outer edges took the greatest number of spat, the number becoming progressively less toward the center of the pile. This is no doubt due to the fact that the batteries were too close

[2] See 1935 report: Calif. Fish and Game, vol. 22, no. 4, pp. 284-293, 1936.

FIG. 18. Spat collector, not yet cemented, as used by Humboldt California Oyster Growers in Humboldt Bay. Photograph by Paul Bonnot, October 1, 1936.

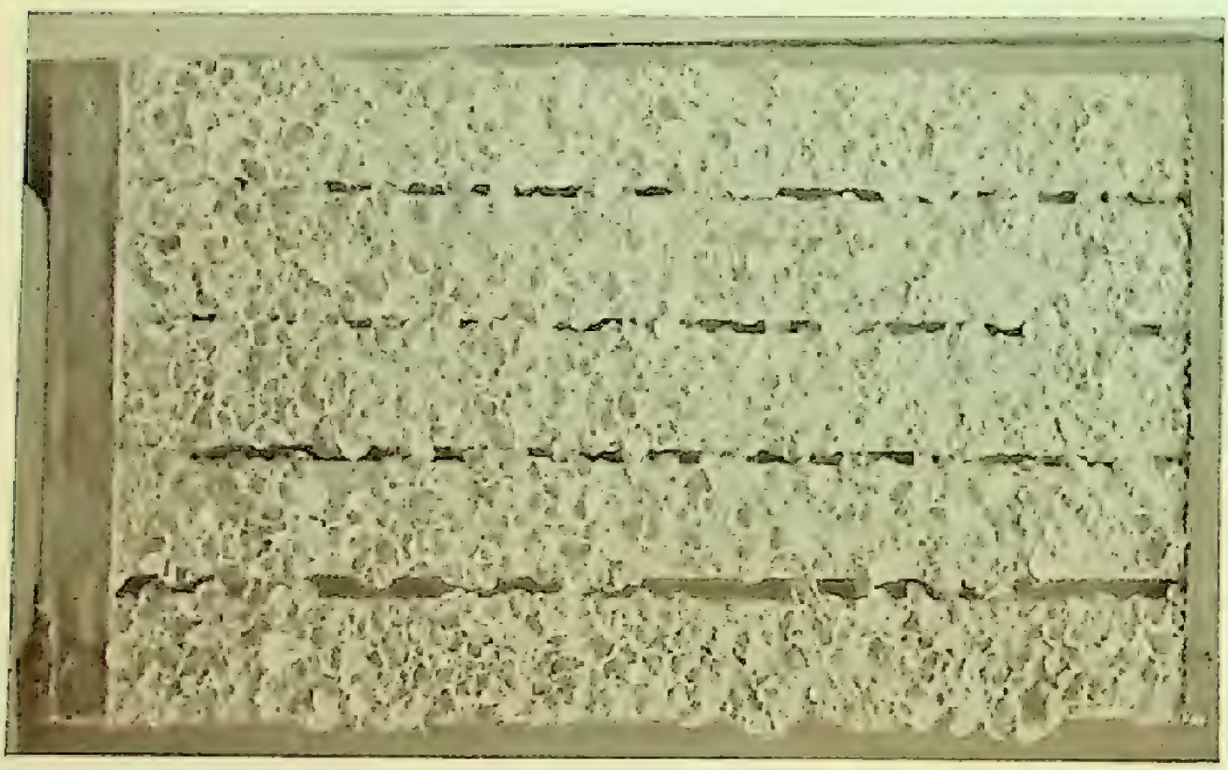

FIG. 19. A spat collector used by Humboldt California Oyster Growers in Humboldt Bay, showing a set of 50 to 60 spat per square inch. Collector put out June 1, 1936. Photograph by M. Green, August 15, 1936.

together; as one battery placed by itself, at some distance from the others, caught almost a uniform set throughout. By making up the batteries in sections of two units instead of four and spacing them farther apart in the dike, the swimming larvae would be able to reach the available surface with greater facility and the set would no doubt be more evenly distributed.

The set started early in the third week of May and by the first of June was increasing at such a rate that the Humboldt California Oyster Growers were advised to put the 4000 collectors they had made in the water. The set reached its first and greatest peak about June 15, afterwards falling and rising several times to progressively smaller highs until the middle of August. The number of spat was very large and the artificial collectors took as many as 60 to the square inch. The different high points of the set curve can be followed in a general way by a study of the size of the spat on the collectors. The spat set during the first peak were nearly ¾-inch in diameter by the time the later peaks materialized and in most cases are themselves set with from three to ten smaller spat. One company made up several thousand egg-crate collectors after the set had started and got them in the water after the largest wave of setting had passed. They took some set; more than any of the collectors in 1935 in fact, but not as many as they should have caught under the circumstances. As they were made up in a hurry the fault may be traceable to a poor cement dip.

Several independent factors or a combination of some factors may account for the heavy set of this season. Oysters seem to spawn and set in greater numbers during some seasons than in others; in some localities maintaining a definite cycle of one good setting year for two or more seasons of poor sets. The data for Humboldt Bay are, as yet, insufficient to determine what the cycle is. There was a fairly heavy set in 1934 although the intensity, distribution and time are not known. As 1936 was also a year of heavy set it may be stated tentatively that the bay will show a heavy set every other year. Several years ago, the natural beds of native oysters were extensively tonged; in some cases being almost denuded of both oysters and shell. After the damage was done the growers themselves realized the dangers of the procedure and the natural beds have not been disturbed for three years. The beds have recovered rapidly due perhaps to the 1934 set, and the oysters on them, together with those caught on the artificial collectors and planted on the prepared beds, have greatly increased the functioning brood stock.

The experimental shell bags give the best comparison of set intensity during the last two seasons. The best bag in 1935, using 150 shells as the unit, took 300 spat; whereas the best bag of 1936, with 100 shells considered the base, took 30,000. In addition to this purely mathematical comparison, it might be pointed out that the 1935 set occurred in two very small waves of only a few days each, whereas the 1936 set was continuous for a period of about three months.

One interesting point noted while counting the spat is the varying age of the young oysters. A little practice soon makes it easy to distinguish the approximate ages and as the shell bags are in the water for one week no spat older than one week will occur. During

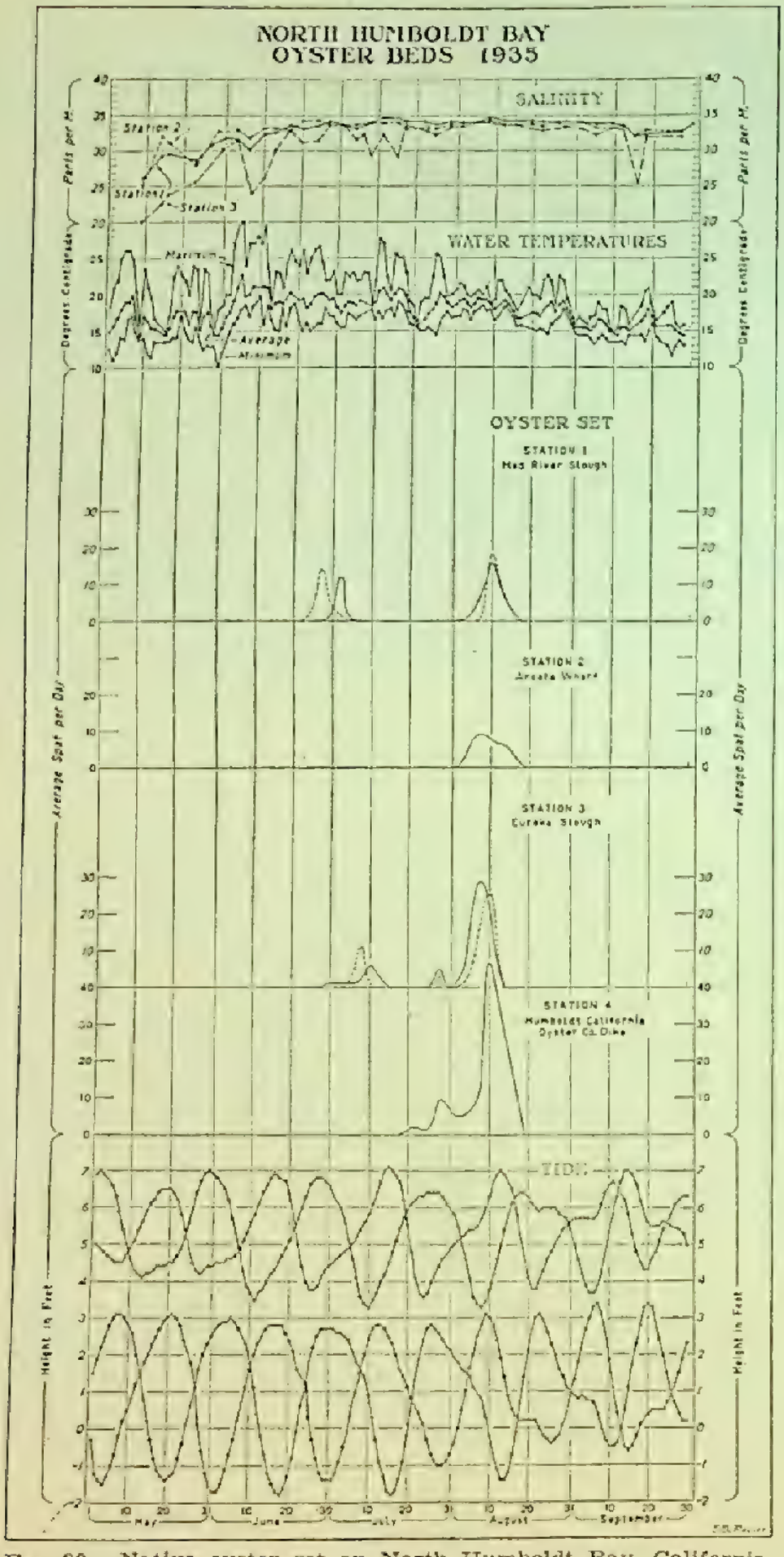


FIG. 20. Native oyster set on North Humboldt Bay, California, in 1935, demonstrating correlation with various factors.

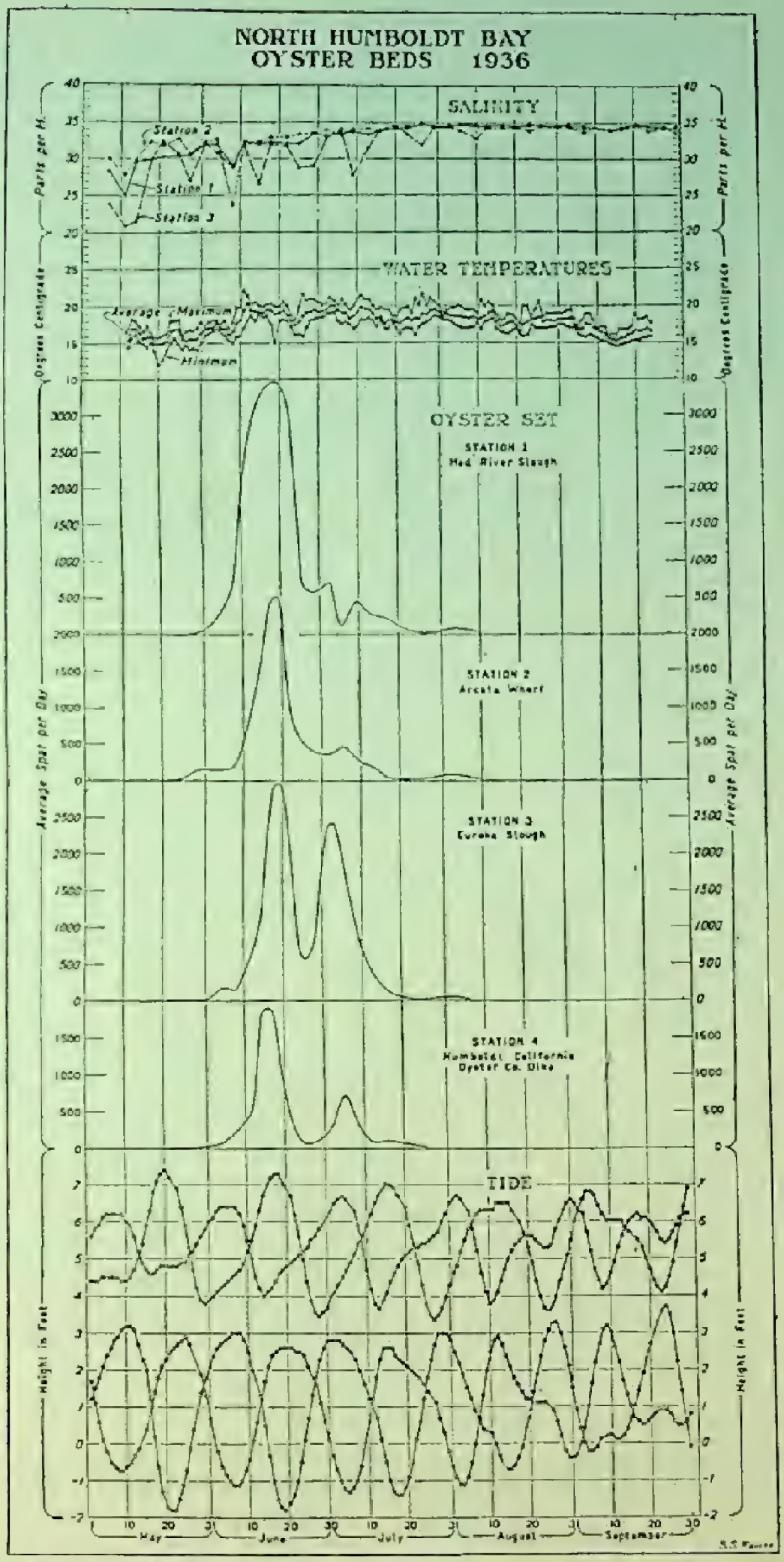


FIG. 21. Native oyster set on North Humboldt Bay, California, in 1936, demonstrating correlation with various factors.

a period of heavy setting, it would be assumed therefore that the spat would show an age graduation between those newly set and others a week old. This, however, does not happen. There are usually two or more distinct age classes. Some bags will have 80 per cent of the spat five or six days old, and 20 per cent not more than twelve hours old. The bag from the same station the following week may have these ratios reversed. It would appear therefore that although the set of any one bag is considered as a total, caught uniformly over a period of seven days, the actual set occurs in several waves within a weekly period. A closer study of this phenomenon may give some idea of the necessary combination of environmental conditions which induce the setting.

For a number of years the oyster growers have complained of losses in their stock which they attributed to crabs. There is a crab (*Cancer productus*) which can and does crack and eat oysters, but its depredations are usually of minor importance. During the early part of May, 1936, a great many native oysters were destroyed in the dikes of the Humboldt California Oyster Growers and an examination disclosed the characteristic signs of sting rays. The common bat ray (*Actobatus californicus*) which causes considerable damage to oysters in the more southern bays was not previously known to enter Humboldt Bay. In fact, the geographical range of the species is given as Cape Mendocino south to Lower California. Although no rays could be found, a stake fence was built around part of the diked area. It required two days to put this fence in, and the upper side was left open over night with the result that two of the rays were left inside the fence by the outgoing tide during the night, proving the actual occurrence of the bat ray in the bay. Although the rays did considerable damage in these dikes, they did not molest natural or artificial beds in other parts of the bay even though none of the others were fenced. Holding a stake fence in position during the winter storms is something of a problem as eel grass and algae tend to pile up against it and the action of rough water will tear it out. However, as the rays are present in the bays only from about the first of May until the middle of August, the fences can be taken up about the first of September. The labor involved is not great and by piling the stakes up on shore and allowing them to dry, they will last much longer as the various wood-boring organisms are killed. Although redwood will outlast other woods when submerged in salt water, it has been found that many species of animals will attack it. The first dikes in Humboldt Bay were built of untreated redwood and at the end of two or three years, nearly all have been replaced as they were totally destroyed. Pressure-creosoted fir is now being used as it has been demonstrated that wood treated in this manner will last for many years.

*Comparison of Data for Humboldt Bay*

Some effort has been made to demonstrate correlations between the setting cycles and environmental conditions, without complete success however (see Figs. 20 and 21). Unless very definite correlations occur in a problem of this kind, two years' data are not sufficient as a basis upon which to draw definite conclusions. The set for 1935

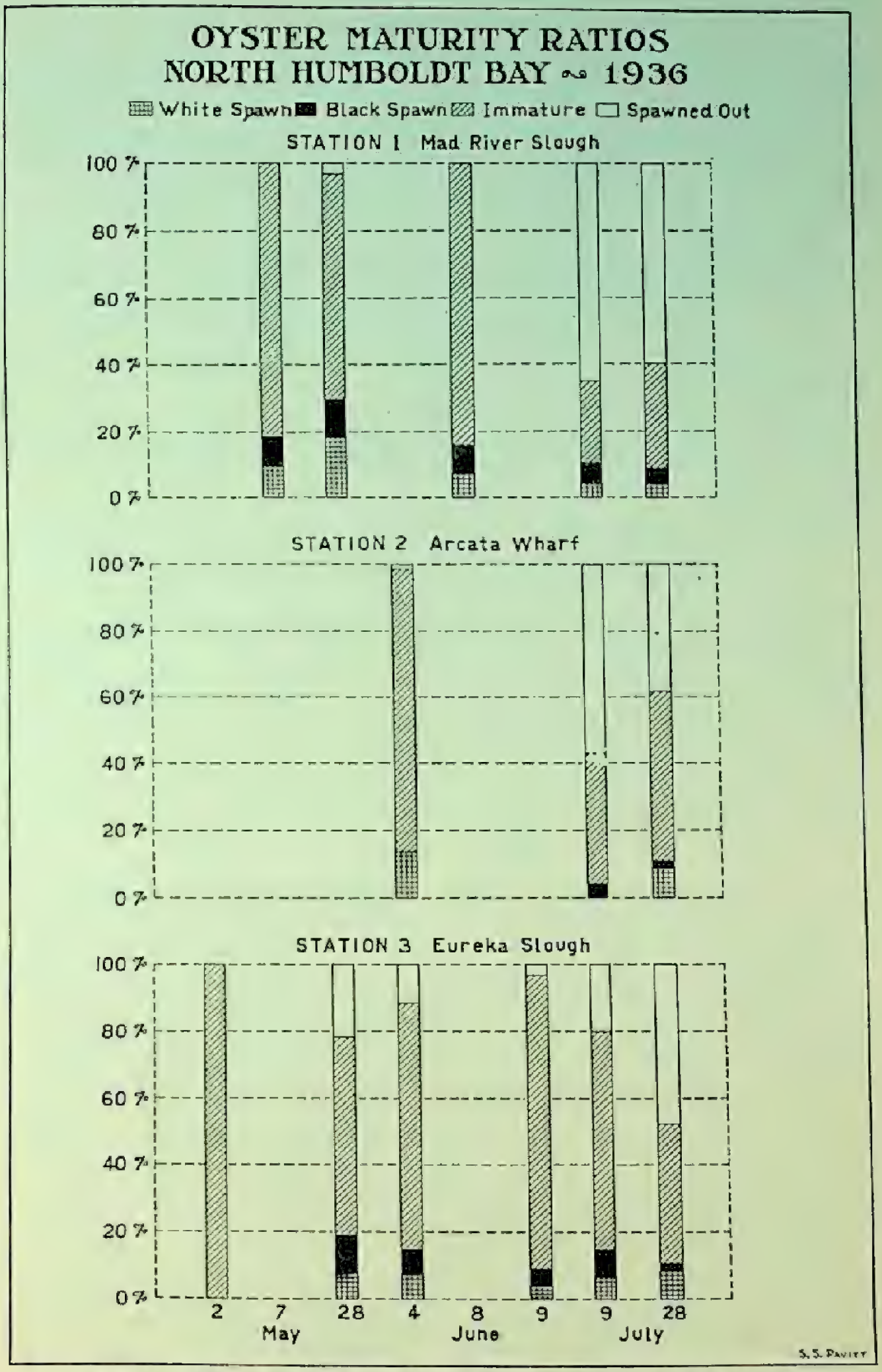


FIG. 22. Maturity ratios of native oysters on North Humboldt Bay, 1936 spawning season.

was very light, whereas that of 1936 was extremely heavy. The water temperatures in 1935 were taken at station 4, in a dike on the eastern side of the bay, whereas the 1936 temperatures were from the Mad River Slough channel near station 1. With these points in mind, a careful comparison of the curves for salinity, temperature and tides for each year and between the two years seems to show some correlation with the set curve. The following points may be significant:

*Temperature*

1935. The average temperature curve follows the set curve to some extent.
1936. There is a distinct correlation between the average temperature curve and the set curve, the peaks of the set curve corresponding to the peaks of the temperature curve. The temperature peaks are in the first two cases 20° C. and in the third 18° C.

*Salinity*

1935. Slight correlation between salinity and set.
1936. About the same degree of correlation as the temperature curve, except that in this case the low points in the two curves correspond.

*Tides*

1935. The set data for this year were not sufficient to show definite relationships, but there seems to be some correlation between the tide and set curves, as suggested by Hopkins; i.e., that a wave of setting which begins during a run of neap tides will reach a peak at or shortly before the succeeding run of spring tides.
1936. A very striking correlation between the set and tide is evident during this season. The set starts on a run of neap tides and reaches the first and greatest peak exactly over the succeeding run of spring tides. After making a very decided drop the set curve rises to a second peak over the next spring tide cycle. It then falls and after missing one series of spring tides rises again over the following run of spring tides. The set did not entirely stop during this whole period but the first peak of the set curve was the highest and each succeeding rise was progressively smaller.

## Eastern Oysters

As it has taken more time to produce native oysters than was at first indicated, permission was granted to the growers by the Division of Fish and Game to introduce eastern oysters (*Ostrea virginica*) and eastern seed oysters. Eastern seed oysters, because of previous failures, have not been grown in California waters for a good many years, but by obtaining seed from the more northern localities on the Atlantic coast, experimentation has shown that they can be successfully grown. A carload of one-year-old stock with some spat set on them was planted on the artificial beds during November of 1935. Both the year-old oysters and the seed have shown a remarkable growth due to the fact that feeding in local waters, with a minimum temperature of 5° C., continues during the winter, whereas the zero temperatures of the east coast cause the oysters to suspend feeding and hibernate. Encouraged by the manner in which the eastern transplants have grown, another car of seed and one-year-old stock was planted in November, 1936. This second shipment consisted of seed set on empty oyster and scallop shells and of one-year-olds still set on the original cultch. These one-year-old oysters should be large enough to be broken up by next spring.

## Japanese Oysters

There are several California bays that do not produce native oysters. Local environmental conditions must be unfavorable as no wild natives are found and the absence of shell deposits indicates that none have ever been there, at least in recent geological time.

Although oysters will not spawn or set in some areas, they will grow satisfactorily if introduced, and experiments have been carried on in the barren bays with Japenese seed oysters. These experiments have extended over a number of years and have shown such encouraging results that several individuals and companies are now planting Japanese seed in California waters in some quantity. The growth of this species in local waters has been remarkable. The oysters in their native environment are accustomed to high water temperatures in summer and very low ones in winter, the range being from 0° to 35° C. The coastal waters of California have a temperature range of from 5° to 22° C. Because the water temperatures do not fall to zero, the transplanted oysters continue to feed and grow during the winter months instead of hibernating. It requires about three years to produce a market size oyster in Japan, whereas seed oysters grown in California reach a salable size in eighteen months. In one California bay under exceptionally favorable conditions, the seed have reached marketable size in eight months.

The future of the Japanese oyster seems assured as a promising canned product. The species adapts itself to canning by its rapid growth. In the can, it holds its shape well, retains its flavor and remains tender. Because of the extremely rapid growth the Japanese is not as desirable for the fresh trade as some of the slower growing species. A large planting can not be disposed of while the oysters are the proper size and a large proportion may be too large to be readily marketable. A canning operation on the other hand can handle large quantities in a short time and would not be inconvenienced by a great disparity in sizes.

Plants of Japanese oyster seed have been made in Bodega Lagoon, Drakes Estero, Tomales Bay, Elkhorn Slough and Morro Bay. Some seed has also been planted in San Francisco and Tomales bays by several oyster companies already engaged in handling imported easterns and natives. The seed is set on old oyster shell and is shipped in wooden cases. The expectation, from a case, with an average set, is 10,000 marketable oysters. The total imports of seed have slowly increased during the last few years.

*Imports of Japanese Oyster Seed*

| | |
|---|---|
| 1933 | 1295 cases |
| 1934 | 1031 cases |
| 1935 | 4902 cases |
| 1936 | 3725 cases |

The figures for 1936 would have been increased by several thousand but for the maritime strike which stopped all shipments during November and December.

# EDITORIALS AND NOTES

VOLUME 23 APRIL, 1937 No. 2

## J. O. SNYDER RESIGNS

It is with sincere regret that the Division of Fish and Game announces the resignation of Dr. J. O. Snyder, Chief of the Bureau of Fish Conservation. Dr. Snyder retired on January 1, 1937, to his home on the campus of Stanford University, at which seat of learning he is Professor Emeritus of Zoology and retired head of the Zoology Department.

Before his appointment as bureau chief in 1932, Dr. Snyder was connected with the Division for many years in various capacities, largely advisory. His research on Pacific salmon and on the fresh-water fishes of California has earned him a place in the front rank of specialists in those fields. It was his work with these fish, and his experience in charting the destinies of his students, that suited him so well for his position as chief of all our fish hatcheries. Under his leadership, a fine spirit developed among the men of the Bureau of Fish Conservation and, working together, they built the Bureau up to its present high standing as one of the leading agencies for game fish propagation and distribution in the United States.

Not only is the Division indebted to Dr. Snyder for his work with the Bureau of Fish Conservation but it also has him to thank for the training of many of its staff, for no less than nine of our administrative and research workers were students of his at Stanford and were guided into the conservation field by him. These include his successor as bureau chief, Alan C. Taft, who is carrying on so well since Dr. Snyder turned the reins over to him.

The Fish and Game Commission and the Division of Fish and Game are proud to have had associated with them a gentlemen of Dr. Snyder's character and reputation in the cause of conservation. We all join in wishing him happiness and success in the future.—*Herbert C. Davis, Executive Officer, California Division of Fish and Game.*

## JOHN P. BABCOCK

Dr. John P. Babcock, well known fisheries expert, died on October 12, 1936, in Victoria, B. C. Dr. Babcock was appointed deputy of the California Fish and Game Commission on April 13, 1891 and in October, 1892 was made chief deputy of the departments of patrol and hatcheries, serving in that capacity until he resigned October 15, 1901. During his years of service the progress made by the California Commission in fisheries research was particularly noted and to him should be given

the credit for laying the foundation that afterwards placed California in the foremost rank of enlightened states on fisheries problems.

The high respect in which he was held is best told by the following resolution adopted by the board on receipt of his resignation:

"WHEREAS after continuous and faithful service to this board of more than eleven years, Mr. John P. Babcock, Chief Deputy, has this day tendered his resignation of that office, in order to accept a position of larger scope and greater emolument under the government of British Columbia; and Whereas the work of Mr. Babcock in the California Fish Commission has ever been marked by energy, fidelity and integrity, be it

*Resolved*, That the resignation aforesaid be accepted with profound regret. That the departure of Mr. Babcock is a distinct loss to the fishery interests of California. That we commend him to his new employers as a gentleman thoroughly equipped for the position he has accepted, as one whose administration of his new office will ever be marked by ability, economy, and success."

In August, 1910, Mr. Babcock was again called to California as chief deputy but only served until November 29, 1911, when he again returned to his fisheries work in British Columbia. When the International Fisheries Commission (United States and Great Britain) was formed in 1924, he was appointed chairman of the halibut research program on the Pacific halibut in United States and Canadian waters, which position he held until his retirement early in 1936, and then served in the capacity of advisor to this commission.—*J. S. Hunter, California Division of Fish and Game.*

## THE WORKS PROGRESS ADMINISTRATION

The Division of Fish and Game wishes to take this opportunity to gratefully acknowledge the assistance being given by the United States Works Progress Administration. This issue of CALIFORNIA FISH AND GAME contains 2 drawings, 9 graphs and 2 maps prepared by draftsman S. S. Pavitt as part of a Works Progress Administration clerical-technical project that is operating at the California State Fisheries Laboratory at Terminal Island. This project (No. 6915), which is only one of several sponsored by the Division, was started in the early days of SERA, has operated continuously and has been of very material aid in preparing biological material and statistical data in a form suitable for publication.—*W. L. Scofield, California State Fisheries Laboratory.*

## STUDY OF OCEAN CURRENTS

During the spring and summer of 1937, the California State Fisheries Laboratory, in cooperation with the Scripps Institution of Oceanography, is undertaking an investigation to determine surface currents in the ocean off the coast of southern California. This program involves the analysis of water samples for the calculation of current directions and velocities, and the release of 6,000 drift bottles between Port San Luis and San Diego and out to sea for some 175 miles. This region is the one in which the major part of the spawning of the California sar-

dine, a very important commercial fish, takes place. The purpose of this experiment is to determine the drift of eggs, larvae and young fish.

The bottles will be released along four station lines which are laid out in a southwesterly direction from Port San Luis, Santa Barbara, San Pedro, and San Diego, respectively. One thousand five hundred bottles will be thrown into the sea along each station line.

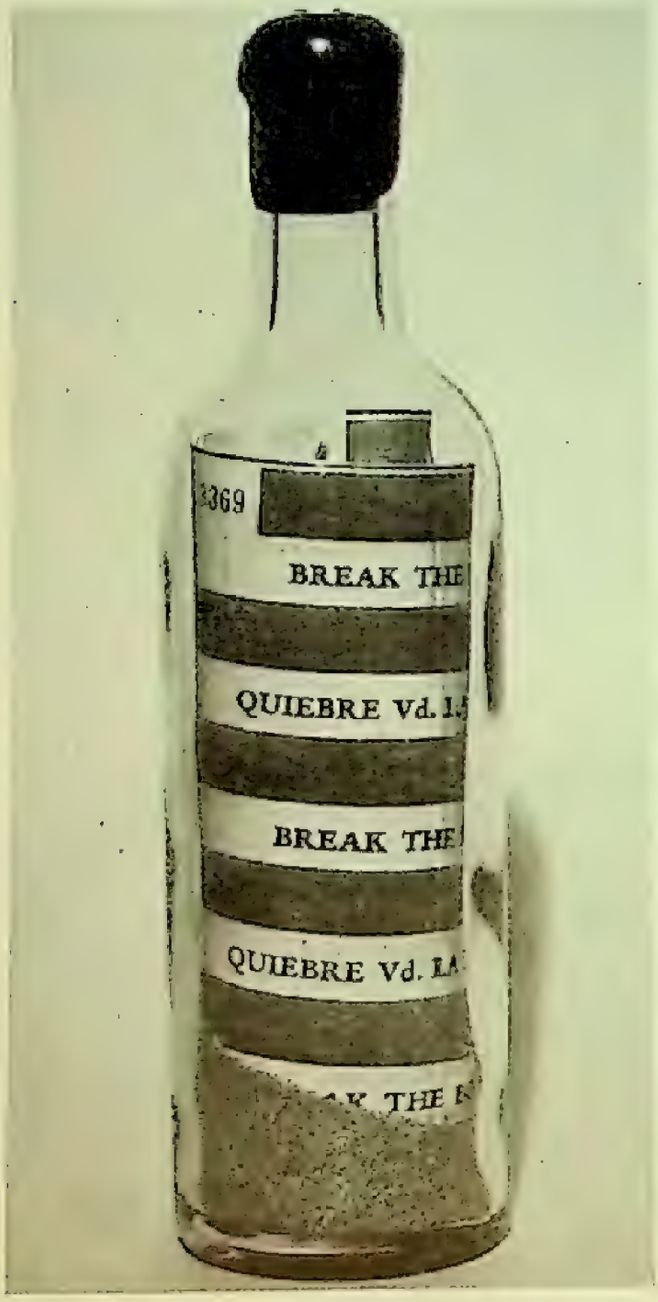


FIG. 23. Type of drift bottle used in a study of ocean currents.

The bottles are 12-ounce wine bottles, corked and with the neck dipped in marine glue. Each bottle contains three sheets of paper. The label, which is visible from the outside, is printed with conspicuous alternating red and white stripes, with instructions in English and Spanish to BREAK THE BOTTLE. Each of these labels is numbered. Inside will be found a sheet of instructions printed in both English and Spanish, telling the finder what the bottle is, its purpose, and requesting him to fill out and mail the third sheet—a postpaid business reply card. This card asks where and when the bottle was found, and the name and address of the finder. The cards are serially numbered to correspond to the number on the outer label. With these data, it will be possible to inform the finder as to where and when the bottle he found was released. The bottles are ballasted with sand until they barely stay afloat. This does away as much as possible with the effects of wind.

It is expected that many of these drift bottles will be washed ashore along the coast and should be picked up by fishermen, swimmers and others. It is requested that people be on the alert for these bottles as the Division of Fish and Game will appreciate the return of the cards which they contain.—*Richard B. Tibby, California State Fisheries Laboratory, March 17, 1937.*

## OCCURRENCE OF EGRETS NEAR LONG BEACH

During the last three or four years, egrets have visited the vicinity of Long Beach in greater numbers than ten or twelve years ago. In the fall of 1925, an egret wading along the flood control channel within the Long Beach city limits was admired by the trolley car commuters as a rarity. At that time, these large white birds were occasionally seen in the marshes at the west end of the city, across the road from where the Ford Motor Company assembly plant now stands. In the fall or early winter one or two egrets might be seen, and by 1928 it was not unusual to see four or five such birds on these tidal flats.

Each fall a few more birds appeared. On November 8, 1935, a total of 16 egrets was counted across from the Ford plant. Of these, 10 were the large American egrets, *Casmerodius albus egretta,* and 6 were the smaller snowy egrets or snowy herons, *Egretta thula brewsteri.* With them were 2 blue herons. On the following day, several of these birds had left the area, as only 4 American egrets, 8 snowy herons and one blue heron were counted.

A year later, on December 16, 1936, a total of 63 egrets was counted on the same marsh. Thirty-two of these were American egrets and 31 were snowy herons. On the following day, but 24 birds were to be seen.

This interesting marsh, which has been so attractive to egrets and many kinds of shore birds, is doomed to be trampled under the advance of commercial development, for oil was discovered under the tide flats in January, 1937. Within two months, trucks were swarming to the scene with earth to make fills and a young forest of oil derricks had sprouted where egrets had pruned their white feathers but a few weeks before.—*W. L. Scofield, California State Fisheries Laboratory, March 10, 1937.*

## MARKED SILVER SALMON FROM WADDELL CREEK CAUGHT NEAR FORT BRAGG

Mr. H. B. Nidever of the Bureau of Commercial Fisheries, while visiting the Paladini receiving plant at Noyo near Fort Bragg, California, on August 8, 1936, obtained a marked silver salmon (*Oncorhynchus kisutch*) which had come in that day. This fish was a male, 56 cm. in length, and had been marked by the removal of the adipose and left pectoral fins. Both silver salmon and steelhead seaward migrants were marked in this manner at Waddell Creek during the spring of 1935. Thus in order to be one of the fish from that marking the fish recovered at Noyo should show one complete and one partial year in the ocean. Examination of the scales shows this to be the case. Scale measurements for the three growth periods were as follows: 1st stream .40 mm., 1st ocean 1.22 mm., 2nd ocean 1.19 mm. This is the typical history of fish from that stream since they almost invariably spend one year in the stream and either one or two years in the ocean. This marked fish would thus have returned as an adult during the coming run in November or December. Noyo is approximately 180 miles northwest of Waddell Creek.

6—43375

Mr. Alex Lambert of the Paladini Company, who first noted the marked silver salmon, reports having seen several others during the course of the season, totalling perhaps four or five.

As this is the first evidence of the movement of silver salmon in the ocean, it is hoped that during the coming year more complete records can be obtained of the marked silver salmon landed in the north coast region.—*A. C. Taft, California Division of Fish and Game, September 28, 1936.*

## A RED SALMON (Oncorhynchus nerka) TAKEN IN THE KLAMATH RIVER

On August 28, 1936, Mr. Van Pelt, proprietor of the hotel at Orleans, California, while fishing near the mouth of Camp Creek, noticed a fish which was colored a much brighter red than is usual in the king salmon. Although it would not take fly or bait he was able to hook it otherwise and brought it to the hotel. Camp Creek is about 55 miles upstream from the mouth of the Klamath.

Upon examination by the writer the following morning, it was believed to be a red salmon. It was a male, 23⅝ inches in length, with greatly prolonged jaws. It was quite evenly colored a bright rosy red, with a greenish tinge to the dorsal fin and the head. A count of the gill rakers on the first arch gave 14–20 on the right side and 14–21 on the left. This gives a total of 34 or 35 which falls well within the limits of the usual counts for red salmon which run from 32 to 40. The other species of Pacific salmon always have 30 or less on the first gill arch.

An examination of scales from this fish was made later and although they were badly absorbed, it was evident that this fish had spent two years in fresh water and at least two in the ocean. In addition the scales showed the reticulations along the margin between the circuli and the posterior portion of the scale, which is typical of red salmon.

Jordan and Evermann give the distribution of *Oncorhynchus nerka* as being from the Klamath northward, but there has previously been no record to substantiate this statement. Scofield (California Fish and Game, vol. 2, no. 1, Jan., 1916) reports that a cannery operator at the mouth of the Klamath stated that about 20 sockeye salmon had been taken in the nets that year. It is probable, however, that the operator was not correct in his identification as it was later found that dog salmon were occasionally reported as sockeyes or red salmon. *O. nerka* is known as red salmon in Alaska, sockeye on Puget Sound and blueback in the Columbia River.—*A. C. Taft, California Division of Fish and Game, September 28, 1936.*

# REPORTS

## STATEMENT OF REVENUE

### For the Period July 1, 1936, to December 31, 1936, of the Eighty-eighth Fiscal Year

| | | |
|---|---|---|
| Revenue for Fish and Game Preservation Fund: | | |
| Current Year: | | |
| License Sales: | | |
| Angling licenses, 1936 | $170,245 00 | |
| Angling licenses, 1937 | 147 00 | |
| Commercial hunting club licenses, 1936-1937 | 750 00 | |
| Commercial hunting club operators' licenses, 1936-1937 | 145 00 | |
| Deer tags, 1936 | 74,870 00 | |
| Fish breeders' licenses, 1936 | 30 00 | |
| Fish importers' licenses, 1936 | 5 00 | |
| Fishing party vessel permits, 1936 | 59 00 | |
| Fish packers and wholesale shellfish dealers' licenses, 1936 | 1,005 00 | |
| Game breeders' licenses, 1936 | 120 00 | |
| Hunting licenses, 1934-1935 | 661 16 | |
| Hunting licenses, 1935-1936 | 10,851 00 | |
| Hunting licenses, 1936-1937 | 170,830 50 | |
| Kelp licenses, 1936 | 10 00 | |
| Market fishermen's licenses, 1936-1937 | 39,520 00 | |
| Trapping licenses, 1936-1937 | 1,359 00 | |
| Total current year | | $479,607 66 |
| Other income: | | |
| Court fines | $40,421 68 | |
| Fish packers' tax | 149,102 00 | |
| Fish tag sales | 1,381 04 | |
| Game tag sales | 148 77 | |
| Importers' contributions | 55 00 | |
| Interest on bank balances | 3,653 48 | |
| Kelp tax | 86 04 | |
| Lease of kelp beds | 1,309 20 | |
| Publication sales | 143 30 | |
| Salmon tax, Chap. 1015-35 | 12,602 20 | |
| Miscellaneous sales | 3,869 97 | |
| Total other income | | $212,773 37 |
| Grand total | | $692,381 03 |

## STATEMENT OF EXPENDITURES

For the Period July 1, 1936, to December 31, 1936, of the Eighty-eighth Fiscal Year

| Function | Salaries and wages | Materials and supplies | Service and expense | Property and equipment | Total |
|---|---|---|---|---|---|
| **Operating Expenditures—88th Fiscal Year:** | | | | | |
| Administration: | | | | | |
| Executive | $2,499 96 | | | | $2,499 96 |
| General office | 2,760 00 | $639 43 | $343 25 | $9 41 | 3,752 09 |
| Printing, general | | 1,055 03 | | | 1,055 03 |
| Automobiles | | 170 35 | 46 27 | | 216 62 |
| Traveling | | | 1,207 46 | | 1,207 46 |
| Postage | | | 2,330 72 | | 2,330 72 |
| Telephone and telegraph | | | 1,466 93 | | 1,466 93 |
| Freight, cartage and express | | | 493 05 | | 493 05 |
| Rent | | | 5,010 85 | | 5,010 85 |
| Accident and death claims | | | 1,019 98 | | 1,019 98 |
| Department administration pro rata | 4,999 99 | | 60 01 | | 5,060 00 |
| Librarian | 900 00 | 105 63 | 31 00 | 71 35 | 1,107 98 |
| Legal | | | 1,682 25 | | 1,682 25 |
| Premiums on bonds | | | 15 00 | | 15 00 |
| Publicity | | | 1,066 60 | | 1,066 60 |
| Pro rata General Fund expense, Chap. 923-33 | | | 1,561 28 | | 1,561 28 |
| Sales tax on sales, deducted from total | | | —1 90 | | —1 90 |
| Total Administration | $11,159 95 | $2,570 44 | $17,232 75 | $80 76 | $31,043 90 |
| Patrol and Law Enforcement: | | | | | |
| Chief and assistants | $7,543 06 | | | | $7,543 06 |
| General office | 2,340 51 | $44 23 | $40 05 | $4 04 | 2,434 83 |
| Automobiles | | 13,394 24 | 5,477 29 | 11,192 45 | 30,063 98 |
| Traveling | | | 24,521 56 | | 24,521 56 |
| Postage | | | 389 78 | | 389 78 |
| Telephone and telegraph | | | 969 58 | | 969 58 |
| Freight, cartage and express | | | 1 29 | | 1 29 |
| Rent | | | 451 48 | | 451 48 |
| Captains and wardens | 103,213 60 | 334 71 | 521 76 | | 104,070 07 |
| Launches | 3,019 57 | 4,919 89 | 3,043 17 | 412 71 | 12,295 34 |
| Premiums on bonds | | | 15 00 | | 15 00 |
| Temporary help | 470 81 | | | | 470 81 |
| Assistant fish and game wardens, seasonal | 11,577 89 | | | | 11,577 89 |
| Heat, light, water and power | | | 1 48 | | 1 48 |
| Total Patrol and Law Enforcement | $129,071 44 | $18,693 07 | $35,432 44 | $11,609 20 | $194,806 15 |
| Commercial Fisheries: | | | | | |
| Chief and assistant | $5,220 00 | | | | $5,220 00 |
| General office | 4,571 61 | $46 34 | $13 20 | $121 81 | 4,752 96 |
| Automobiles | | 205 53 | 88 36 | 623 15 | 917 04 |
| Travel | | | 3,668 89 | | 3,668 89 |
| Telephone and telegraph | | | 410 85 | | 410 85 |
| Freight, cartage and express | | | 81 53 | | 81 53 |
| Rent | | | 90 46 | | 90 46 |
| Heat, light, water and power | | | 201 84 | | 201 84 |
| Research (oyster) | 1,140 00 | 13 07 | | | 1,153 07 |
| Laboratory | 14,574 52 | 1,318 67 | 346 64 | 673 32 | 16,913 15 |
| Fish tags | | 177 98 | | | 177 98 |
| Cooperative research | | | 500 00 | | 500 00 |
| Statistics | | 136 09 | 1,068 47 | | 1,203 46 |
| Temporary help | 527 42 | | | | 527 42 |
| Terminal Island Gds. | 450 00 | 7 83 | 2 43 | | 460 26 |
| Fish cannery auditing | | | 545 00 | | 545 00 |
| Total Commercial Fisheries | $26,483 55 | $1,906 41 | $7,017 67 | $1,418 28 | $36,825 91 |
| Fish Conservation: | | | | | |
| Chief and assistants | $3,630 00 | | | | $3,630 00 |
| General office | 2,558 72 | $5 27 | $3 40 | | 2,567 39 |
| Automobiles | | 4,867 62 | 1,397 68 | $9 19 | 6,274 49 |
| Traveling | | | 5,700 85 | | 5,700 85 |
| Postage | | | 93 94 | | 93 94 |
| Telephone and telegraph | | | 519 43 | | 519 43 |
| Freight, cartage and express | | | 144 79 | | 144 79 |
| Rent | | | 490 49 | | 490 49 |
| Heat, light, water and power | | | 875 41 | | 875 41 |
| Fish planting | | 599 69 | 1,672 50 | 14 30 | 2,286 49 |
| Research | | | 224 19 | | 224 19 |
| Hatcheries | 54,985 15 | 23,783 12 | 325 64 | 542 92 | 79,636 83 |
| Fish cars | 900 00 | 1 44 | 925 39 | | 1,826 83 |
| Cooperative research | 1,283 23 | 128 30 | 135 08 | 21 33 | 1,567 94 |
| Statistical | 696 78 | 77 | 534 10 | | 1,231 65 |

## STATEMENT OF EXPENDITURES

For the Period July 1, 1936, to December 31, 1936, of the Eighty-eighth Fiscal Year—Continued

| Function | Salaries and wages | Materials and supplies | Service and expense | Property and equipment | Total |
|---|---|---|---|---|---|
| Fish Conservation—Continued | | | | | |
| Temporary help | 256 44 | | | | 256 44 |
| Special field | 6,780 00 | 6 30 | 5 21 | | 6,791 51 |
| Fish rescue | 960 00 | | 25 50 | | 985 50 |
| Assistant fish and game wardens, seasonal | 14,062 70 | | | | 14,062 70 |
| Total Fish Conservation | $86,113 02 | $20,392 51 | $13,073 60 | $587 74 | $129,166 87 |
| Hydraulics: | | | | | |
| Chief and assistant | $3,787 96 | | | | $3,787 96 |
| General office | 960 00 | $17 96 | $5 86 | $16 80 | 1,000 62 |
| Automobiles | | 133 99 | 41 67 | 10 97 | 186 63 |
| Traveling | | | 1,391 62 | | 1,391 62 |
| Telephone and telegraph | | | 1 20 | | 1 20 |
| Blue printing | | | 20 31 | | 20 31 |
| Temporary help | 84 64 | | | | 84 64 |
| Total Hydraulics | $4,832 60 | $151 95 | $1,460 66 | $27 77 | $6,472 98 |
| Game Conservation: | | | | | |
| Chief and assistants | $6,923 31 | | | | $6,923 31 |
| General office | 2,100 00 | $13 91 | $19 73 | | 2,133 64 |
| Automobiles | | 1,155 22 | 307 05 | $776 94 | 2,239 21 |
| Traveling | | | 1,870 72 | | 1,870 72 |
| Telephone and telegraph | | | 218 66 | | 218 66 |
| Freight, cartage and express | | | 77 81 | | 77 81 |
| Heat, light, water and power | | | 1,787 73 | | 1,787 73 |
| Maintenance of game farms | 5,664 97 | 8,890 75 | 150 71 | 553 47 | 15,259 90 |
| Statistics | 209 03 | 1 22 | 533 07 | | 743 32 |
| Temporary help | 3,245 72 | | | | 3,245 72 |
| Maintenance of game refuge | 3,158 00 | 123 62 | 84 52 | | 3,366 14 |
| Total Game Conservation | $21,301 03 | $10,184 72 | $5,050 00 | $1,330 41 | $37,866 16 |
| Licenses: | | | | | |
| General office | $7,260 00 | $3 61 | $107 03 | $2 16 | $7,372 80 |
| Printing licenses and applications | | 1,803 58 | | | 1,803 58 |
| Traveling | | | 230 29 | | 230 29 |
| Postage | | | 826 82 | | 826 82 |
| Freight, cartage and express | | | 43 30 | | 43 39 |
| Premiums on bonds | | | 936 65 | | 936 65 |
| Identification license buttons | | 5,567 77 | | | 5,567 77 |
| License commissions | | | 33,770 26 | | 33,770 26 |
| Total licenses | $7,260 00 | $7,374 96 | $35,923 44 | $2 16 | $50,560 56 |
| Special Item: | | | | | |
| State Fair and other exhibits (Payable from Support, Chapter 341-35 or E. O. for Support) | $40 00 | $117 37 | $1,200 00 | | $1,357 37 |
| Total, 88th Fiscal Year: | | | | | |
| Expense paid from Support | $286,261 59 | $70,391 43 | $116,390 56 | $15,056 32 | $488,099 90 |
| Prior year, 87th fiscal year, for Support | | | | | $12,017 14 |
| Total, 87th and 88th fiscal years, for Support | | | | | $500,117 04 |
| Special Items: | | | | | |
| Predatory Animal Control: | | | | | |
| 88th fiscal year: | | | | | |
| Chief and assistant | $1,050 00 | | | | $1,050 00 |
| General office | 480 00 | | | $25 00 | 505 00 |
| Automobiles | | $1,234 14 | $241 78 | 13 12 | 1,489 04 |
| Traveling | | | 1,216 23 | | 1,216 23 |
| Predatory Animal Control | 7,348 22 | 30 47 | 2,497 33 | | 9,876 02 |
| Predatory animal hunters and trappers | 3,000 00 | | | | 3,000 00 |
| Total, 88th fiscal year | $12,778 22 | $1,264 61 | $3,955 34 | $38 12 | $18,036 29 |

## STATEMENT OF EXPENDITURES

**For the Period July 1, 1936, to December 31, 1936, of the Eighty-eighth Fiscal Year—Continued**

| Function | Salaries and wages | Materials and supplies | Service and expense | Property and equipment | Total |
|---|---|---|---|---|---|
| Prior year, 87th fiscal year, special item—Predatory Animal Control | | | | | $68 25 |
| Total Predatory Animal Control, 87th and 88th fiscal years | | | | | 18,104 54 |
| Total operating expenditures, 87th and 88th fiscal years | | | | | $518,221 58 |
| Expenditures for additions and betterments: | | | | | |
| Permanent improvements: | | | | | |
| Purchase of game refuges and public shooting grounds and construction, improvements and equipment, Chap. 341-35 | $11,552 33 | $12,913 47 | $6,829 10 | $13,852 96 | $45,147 86 |
| Prior year, 87th fiscal year: | | | | | |
| Construction, improvements and equipment and purchase of game refuges and public shooting grounds, Chap. 341-35, all objects | | | | | $1,904 96 |
| Total permanent improvements, 87th and 88th fiscal years | | | | | $47,052 82 |
| Grand total | | | | | $565,274 40 |
| Contributions to Employees' Retirement System, 88th fiscal year | | | | | $3,074 83 |
| Total current biennium | | | | | $568,349 23 |
| Prior biennium appropriations: | | | | | |
| Operating expenditures: | | | | | |
| Special item—Claim of Chief Accounting Officer, Department of Finance, Chap. 991-33 | | | | | —71 00 |
| Special item—Construction of Russian River Jetties, Chap. 989-33: | | | | | |
| 88th fiscal year | | | | | 117 50 |
| Total operating expenditures | | | | | $46 50 |
| Grand total | | | | | $568,395 73 |

## SEIZURES OF FISH AND GAME

**October, November, December, 1936**

| Game: | | Fish: | |
|---|---|---|---|
| Deer | 18 | Abalone | 98 |
| Deer hides | 7 | Bass, black | 63 |
| Deer meat, pounds | 1,085½ | Bass, striped | 187 |
| Doves | 128 | Catfish | 21 |
| Ducks | 970 | Clams | 1,344 |
| Geese | 41 | Crabs | 67 |
| Grebe | 2 | Crappie | 2 |
| Grouse | 4 | Live car | 1 |
| Meadowlark | 2 | Lobsters | 315 |
| Mudhens | 3 | Lobsters, pounds | 165 |
| Non-game birds | 11 | Perch | 12 |
| Pheasant | 93 | Salmon | 62 |
| Pigeon | 1 | Salmon, pounds | 200 |
| Plover | 52 | Skipjack, pounds | 51,284 |
| Quail | 442 | Sturgeon, pounds | 62 |
| Rabbit | 8 | Sunfish | 10 |
| Rail | 1 | Trap | 1 |
| Swan | 2 | Trammel net | 1,500ft. |
| Tree squirrel | 1 | Trout | 129 |
| Tree squirrel hides | 3 | Yellowfin tuna, pounds | 52,123 |

## GAME CASES

**October, November, December, 1938**

| Offense | Number arrests | Fines imposed | Jail sentences (days) |
|---|---|---|---|
| Antelope; possession buck | 3 | $100 00 | |
| Deer; killing doe, fawn, spike buck, spotted fawn; closed season; closed district; failure to retain hide and horns; failure to return tags; mutilating tags; transferring tags; failure to mark packages | 123 | 3,906 00 | 1,082 |
| Doves; closed season; overlimit | 15 | 075 00 | |
| Ducks; closed season; overlimit | 32 | 2,095 00 | 270 |
| Elk; possession | 3 | | |
| Firearms in refuge | 32 | 345 00 | 37½ |
| Geese; overlimit | 11 | 325 00 | |
| Grouse; possession | 3 | 300 00 | |
| Hunting; no license; borrowing, transferring license; alien using citizen's license; failure to show game on demand; closed district | 102 | 1,316 00 | 44½ |
| Illegal shooting | 36 | 552 50 | |
| Mountain sheep; possession | 1 | 50 00 | |
| Night hunting | 8 | 235 00 | |
| Non-game birds; killing; possession; closed season | 15 | 247 50 | |
| Pheasant; closed season; overlimit; shipping in closed packages | 60 | 2,070 00 | 55 |
| Pigeon; closed season | 1 | 25 00 | |
| Poisoning birds | 1 | 25 00 | |
| Protected game birds; possession | 6 | 25 00 | 120 |
| Quail; closed season; overlimit; trapping | 32 | 475 00 | |
| Rabbits; closed season | 6 | 150 00 | 2 |
| Robins; killing | 1 | 25 00 | |
| Spotlighting | 10 | 195 00 | 10 |
| Swan; possession | 1 | 25 00 | |
| Trapping; bear; game birds | 2 | | 10 |
| Tree squirrels; killing; possession | 3 | 25 00 | |
| Totals | 507 | $13,493 00 | 1,631 |

## FISH CASES

**October, November, December, 1938**

| Offense | Number arrests | Fines imposed | Jail sentences (days) |
|---|---|---|---|
| Abalones; overlimit; undersize | 61 | $1,190 00 | |
| Bass, black; undersize | 10 | 195 00 | |
| Bass, striped; overlimit; undersize; selling | 20 | 520 00 | 60 |
| Clams; overlimit; undersize; out of shell; failure to show on demand; taken in preserve | 50 | 801 50 | 432½ |
| Commercial fishing; failure to keep records; no license | 33 | 160 00 | |
| Crabs; undersize | 11 | 185 00 | |
| Fishing; failure to provide passage over dam; too near dam, fishway; closed district; using prohibited gear; failure to show license on demand; transferring license; using another's license | 141 | 2,174 00 | 112 |
| Lobsters; closed season; undersize | 6 | 115 00 | |
| Night fishing | 16 | 330 00 | |
| Pollution | 8 | 440 00 | |
| Sardines; reducing without permit | 1 | 100 00 | |
| Salmon; spearing; overlimit | 12 | 155 00 | 30 |
| Skipjack; selling undersize | 3 | 50 00 | |
| Steelhead; overlimit | 2 | 25 00 | |
| Sturgeon; possession | 1 | 20 00 | |
| Trout; overlimit; using fresh spawn; using two poles; closed season | 8 | 215 00 | |
| Tuna, yellowfin; selling undersize | 3 | 50 00 | |
| Totals | 392 | $6,725 50 | 634½ |

## CALIFORNIA FRESH FISH LANDINGS* FOR OCTOBER, NOVEMBER AND DECEMBER, 1936

Compiled by the Division of Fish and Game, Bureau of Commercial Fisheries

| Species | Region 10, Del Norte | Region 20, Eureka | Region 30, Sacramento | Region 40, San Francisco | Region 50, Monterey | Region 60, Santa Barbara | Region 70, Los Angeles | Region 80, San Diego | Total pounds |
|---|---|---|---|---|---|---|---|---|---|
| Anchovy | | 2,020 | | | | | 300 | | 2,320 |
| Barracuda | | | | | | 6,786 | 211,412 | 128,878 | 347,076 |
| Cabezone | | | | 300 | 1,107 | | | | 1,407 |
| Cabrilla | | | | | | | 6,170 | 10,349 | 16,519 |
| Carp | | | 24,843 | | | | | | 24,843 |
| Catfish | | | 148,679 | | | | | | 148,679 |
| Corbina, Mexican | | | | | | | | 1,000 | 1,000 |
| Cultus, Pacific | 4,823 | 47,148 | | 100,931 | 49,190 | | 311 | 1,846 | 204,249 |
| Eel | | | | 4 | | | | | 4 |
| Flounder, Starry | 5 | 140 | | 139,439 | 423 | | | | 140,007 |
| Flying Fish | | | | | | | 725 | | 725 |
| Grouper | | | | | | | 2,368 | 587 | 2,955 |
| Hake | | | | 19,620 | | | | | 19,620 |
| Halibut, California | | | | 2,678 | 2,133 | 78,148 | 36,041 | 118,688 | 238,288 |
| Hardhead | | | 32,249 | | | | | | 32,249 |
| Herring, Pacific | | 75 | | 91,400 | | | | 1,527 | 93,002 |
| Kingfish | | | | 175 | 58,359 | 269 | 94,316 | 769 | 153,888 |
| Mackerel, Horse | | | | | 5,248 | | 2,097,796 | | 2,103,044 |
| Mackerel, Pacific | | | | 17,321 | 322,962 | 11,058 | 30,178,836 | 2,879,704 | 33,409,884 |
| Mackerel, Spanish | | | | | | | 13,451 | 1,875 | 15,326 |
| Mullet | | | | | | | 3,504 | | 3,504 |
| Perch | | 185 | | 24,974 | 1,614 | 28 | 12,414 | | 39,215 |
| Pike | | | 25 | | | | | | 25 |
| Pompano, California | | | | | | | 1,772 | 15 | 1,787 |
| Rock Bass | | | | | | 1,395 | 36,104 | 35,678 | 73,177 |
| Rockfish | 17,518 | 36,944 | | 240,516 | 498,083 | 47,932 | 64,561 | 39,379 | 950,933 |
| Sablefish | | 29,639 | | 783 | 56,476 | | 40,577 | | 127,475 |
| Salmon | | | 100 | | | | | | 100 |
| Sand Dab | | | | 107,589 | 3,454 | | 1,597 | | 112,640 |
| Sardine | | | 106,861,000 | 91,126,529 | 210,621,925 | 60 | 36,707,223 | 500 | 445,317,236 |
| Sculpin | | | | | | | 28,103 | 1,058 | 29,161 |
| Sea-bass, Black | | | | | | 209 | 70,658 | 29,654 | 100,521 |
| Sea-bass, Short-fin | | | | | | | | 5 | 5 |
| Sea-bass, Totuava | | | | | | | 251,831 | 41,958 | 293,789 |
| Sea-bass, White | | | | 360 | 311 | 28,073 | 44,339 | 39,223 | 112,306 |
| Sea-trout, California | | | | 7 | | | | | 7 |
| Shark | | | | 60,546 | 2,049 | 4,014 | 30,525 | 21,836 | 118,970 |
| Sheepshead | | | | | | 8,635 | 42,074 | 7,917 | 58,626 |
| Skate | | | | 79,792 | 2,900 | 2,250 | 4,039 | 1,360 | 90,341 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Smelt | | 3,773 | | 66,441 | 32,056 | 686 | 83,091 | 1,708 | 187,755 |
| Sole | 052 | | | 1,500,413 | 8,350 | 70,760 | 577 | 10 | 1,590,098 |
| Split-tail | | | 3,346 | | | | | | 3,346 |
| Swordfish, Broadbill | | | | | | 341 | 4,084 | 465 | 4,890 |
| Swordfish, Marlin | | | | | | | 165 | | 165 |
| Tomcod | | | | 763 | | | | | 763 |
| Tuna, Albacore | | | | | 23,030 | 188 | 351,468 | | 374,692 |
| Tuna, Bluefin | | | | | | 3,505 | 260,170 | 24,211 | 287,886 |
| Tuna, Bonito | | | | | 425 | 3,998 | 219,750 | 520,116 | 744,289 |
| Tuna, Mebachi | | | | | | | 20,370 | | 20,370 |
| Tuna, Oriental | | | | | | | 59,390 | | 59,390 |
| Tuna, Skipjack | | | | | | 7 | 3,504,905 | 6,851,615 | 10,356,527 |
| Tuna, Yellowfin | | | | | | 30 | 4,075,548 | 15,289,954 | 19,365,532 |
| Turbot | | | | 15,185 | 2,446 | | | | 17,631 |
| Whitefish | | | | | | 432 | 5,724 | 7,630 | 13,786 |
| Yellowtail | | | | | | | 173,167 | 1,863,656 | 2,036,823 |
| Miscellaneous fish | | 1,341 | | 39,325 | | 2,123 | 982 | | 43,771 |
| Crustacean: | | | | | | | | | |
| Crab | 80 | 6,516 | | 575,340 | 4,584 | | | | 586,520 |
| Crab, Rock | | | | | | | 1,628 | | 1,628 |
| Lobster, Spiny | | | | | | 107,993 | 190,038 | 246,801 | 544,832 |
| Prawn | | | | | 499 | | | | 499 |
| Shrimp | | | | 303,126 | | | 7,670 | 4,489 | 315,285 |
| Mollusk: | | | | | | | | | |
| Abalone | | | | | 150,075 | 455,665 | 210 | | 605,950 |
| Clam, Cockle | | | | 82 | | | 6,264 | | 6,346 |
| Clam, Gaper | | | | 282 | | | | | 282 |
| Clam, Pismo | | | | | 8,909 | 41,117 | | | 50,026 |
| Clam, Soft-shell | | | | 12,051 | | | | | 12,051 |
| Clam, Washington | | 12,799 | | 452 | | | | | 13,251 |
| Mussel | | | | | 150 | | | | 150 |
| Octopus | | 262 | | 365 | 3,498 | | 530 | | 4,655 |
| Oyster, Eastern | | | | 94,220 | | | | | 94,220 |
| Oyster, Japanese | | | | 114,366 | 270 | | | | 114,636 |
| Oyster, Native | | | | 7,064 | | | | | 7,064 |
| Squid | | | | 1,468 | 105,082 | | 166 | | 107,316 |
| Total pounds | 23,378 | 140,842 | 107,070,242 | 94,749,940 | 211,066,220 | 885 702 | 78,947,543 | 28,174,461 | 521,958,328 |

* Importations of fresh fish from foreign countries included. See foreign importation tables.

## FRESH FISH IMPORTATIONS* FROM FOREIGN COUNTRIES FOR OCTOBER, NOVEMBER AND DECEMBER, 1936

Compiled by the Division of Fish and Game, Bureau of Commercial Fisheries

| Species | Landed in Region 70, Los Angeles | Landed in Region 80, San Diego | Total pounds |
|---|---|---|---|
| Barracuda | 123,264 | 125,204 | 248,468 |
| Cabrilla | 6,170 | 10,349 | 16,519 |
| Corbina, Mexican | | 1,000 | 1,000 |
| Cultus, Pacific | 275 | 1,803 | 2,078 |
| Grouper | 2,368 | 587 | 2,955 |
| Halibut, California | 9,732 | 88,473 | 98,205 |
| Mackerel, Pacific | | 780 | 780 |
| Mackerel, Spanish | 13,451 | 1,875 | 15,326 |
| Rock Bass | 3,083 | 13,825 | 16,908 |
| Rockfish | 7,306 | 18,541 | 25,847 |
| Sablefish | 13,904 | | 13,904 |
| Sardine | | 104 | 104 |
| Sea-bass, Black | 69,897 | 27,474 | 97,371 |
| Sea-bass, Totuava | 251,831 | 41,958 | 293,789 |
| Sea-bass, White | 9,396 | 33,332 | 42,728 |
| Shark | 1,547 | 953 | 2,500 |
| Sheepshead | 1,218 | 3,736 | 4,954 |
| Skate | | 1,360 | 1,360 |
| Smelt | | 1,227 | 1,227 |
| Swordfish, Broadbill | | 224 | 224 |
| Tuna, Albacore | 199,614 | | 199,614 |
| Tuna, Bluefin | 1,176 | 5,822 | 6,998 |
| Tuna, Bonito | 68,643 | 362,534 | 431,177 |
| Tuna, Mebachi | 20,370 | | 20,370 |
| Tuna, Oriental | 59,390 | | 59,390 |
| Tuna, Skipjack | 2,164,442 | 6,664,587 | 8,829,029 |
| Tuna, Yellowfin | 4,016,733 | 15,254,395 | 19,271,128 |
| Whitefish | 1,936 | 3,774 | 5,710 |
| Yellowtail | 173,009 | 1,854,080 | 2,027,089 |
| Miscellaneous fish | 74 | | 74 |
| Crustacean: | | | |
| Lobster, Spiny | 25,280 | 168,744 | 194,024 |
| Shrimp | 7,670 | 4,489 | 12,159 |
| Total pounds | 7,251,779 | 24,691,230 | 31,943,009 |

* These importations are included in tables of landings. They include fish caught by California boats in foreign waters as well as frozen fish imported for canning in California plants.

## FRESH FISH IMPORTATIONS BY POINT OF ORIGIN* FOR OCTOBER, NOVEMBER AND DECEMBER, 1936

Compiled by the Division of Fish and Game, Bureau of Commercial Fisheries

| Species | Gulf of California | West coast Lower California | International waters south U. S. boundary (definite origin unknown) | Mexican Mainland, Central and South America | Japan | Total pounds |
|---|---|---|---|---|---|---|
| Barracuda | | 248,468 | | | | 248,468 |
| Cabrilla | 5,158 | 11,361 | | | | 16,519 |
| Corbina, Mexican | 1,000 | | | | | 1,000 |
| Cultus, Pacific | | 2,078 | | | | 2,078 |
| Grouper | | 2,955 | | | | 2,955 |
| Halibut, California | | 98,205 | | | | 98,205 |
| Mackerel, Pacific | | 780 | | | | 780 |
| Mackerel, Spanish | 450 | 14,876 | | | | 15,326 |
| Rock Bass | | 16,908 | | | | 16,908 |
| Rockfish | | 25,847 | | | | 25,847 |
| Sablefish | | 13,904 | | | | 13,904 |
| Sardine | | 104 | | | | 104 |
| Sea-bass, Black | 125 | 89,878 | 7,368 | | | 97,371 |
| Sea-bass, Totuava | 293,789 | | | | | 293,789 |
| Sea-bass, White | | 42,728 | | | | 42,728 |
| Shark | | 2,500 | | | | 2,500 |
| Sheepshead | | 4,954 | | | | 4,954 |
| Skate | | 1,360 | | | | 1,360 |
| Smelt | | 1,227 | | | | 1,227 |
| Swordfish, Broadbill | | 224 | | | | 224 |
| Tuna, Albacore | | | | | 199,614 | 199,614 |
| Tuna, Bluefin | | 6,998 | | | | 6,998 |
| Tuna, Bonito | | 427,967 | 3,210 | | | 431,177 |
| Tuna, Mebachi | | | | | 20,370 | 20,370 |
| Tuna, Oriental | | | | | 59,390 | 59,390 |
| Tuna, Skipjack | | 2,677,838 | 5,089,193 | 16,951 | 1,045,047 | 8,829,029 |
| Tuna, Yellowfin | | 1,047,432 | 16,685,253 | 1,538,443 | | 19,271,128 |
| Whitefish | | 5,710 | | | | 5,710 |
| Yellowtail | | 1,832,552 | 194,537 | | | 2,027,089 |
| Miscellaneous fish | | 74 | | | | 74 |
| Crustacean: | | | | | | |
| Lobster, Spiny | | 194,024 | | | | 194,024 |
| Shrimp | 7,670 | 4,489 | | | | 12,159 |
| Total pounds | 308,192 | 6,775,441 | 21,979,561 | 1,555,394 | 1,324,421 | 31,943,009 |

* These importations are included in tables of landings. They include fish caught by California boats in foreign waters as well as frozen fish imported for canning in California plants.

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# BUREAU OF PATROL

E. L. MACAULAY, Chief of Patrol.....San Francisco

## CENTRAL DISTRICT (Headquarters, Sacramento)

S. H. Lyons, Inspector in Charge.....Sacramento
L. E. Mercer, Warden, Flying Squad.....Sacramento
Ed Hughes, Assistant Warden, Flying Squad.....Sacramento
Chas. Sibeck, Warden, Launch "Rainbow".....Sacramento

### Northern Division

Jos. H. Sanders, Captain in Charge.....Sacramento
A. H. Willard, Captain.....Nevada City
_____, Sergeant.....Redding
A. A. Jordan, Warden, Modoc County.....Alturas
Brice Hammack, Warden, Siskiyou County.....Yreka
Fred R. Starr, Warden, Siskiyou County.....Dorris
C. L. Gourley, Warden, Trinity County.....Weaverville
Chas. Love, Warden, Shasta County.....Redding
C. O. Fisher, Warden, Lassen County.....Susanville
W. C. Blewett, Warden, Plumas County.....Quincy
R. W. Anderson, Warden, Tehama County.....Red Bluff
E. C. Vail, Warden, Glenn County.....Willows
E. O. Wraith, Warden, Butte County.....Chico
A. Granstrom, Warden, Sierra County.....Downieville
Earl Hiscox, Warden, Nevada County.....Nevada City
R. A. Tinnin, Warden, Yuba County.....Challenge
L. W. Dinsdale, Warden, Sutter County.....Yuba City
Taylor London, Warden, Colusa County.....Colusa
R. L. Sinkey, Warden, Yolo County.....Woodland
W. J. Black, Warden, Solano County.....Suisun
H. S. Vary, Warden, Sacramento County.....Sacramento
Nelson Poole, Warden, Placer County.....Auburn
Albert Sears, Warden, El Dorado County.....Placerville

### Southern Division

S. R. Gilloon, Captain in Charge.....Fresno
John O'Connell, Captain.....Stockton
_____ Sergeant.....Bakersfield
Wm. Hoppe, Warden, San Joaquin County.....Lodi
R. J. Little, Warden, Amador County.....Jackson
J. W. Thornburg, Warden, Calaveras County.....Angels Camp
F. F. Johnston, Warden, Tuolumne County.....Sonora
Geo. Magladry, Warden, Stanislaus County.....Modesto
M. S. Clark, Warden, Merced County.....Merced
Ray Ellis, Warden, Kings County.....Hanford
Clarence Brown, Warden, Mariposa County.....Mariposa
H. E. Black, Warden, Madera County.....Madera
Paul Kehrer, Warden, Fresno County.....Fresno
F. A. Bullard, Warden, Fresno County.....Reedley
R. J. Bullard, Warden, Tulare County.....Porterville
W. I. Long, Warden, Tulare County.....Visalia
C. S. Donham, Warden, Merced County.....Gustine
Lester Arnold, Warden, Kern County.....Bakersfield
Roswell Welch, Warden, Kern County.....Kernville

## COAST DISTRICT (Headquarters, San Francisco)

K. P. Allred, Inspector in Charge.....San Francisco
Scott Feland, Warden, Flying Squad.....San Francisco
Eugene Durney, Assistant Warden, Flying Squad.....San Francisco

### Northern Division

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J. D. Dondero, Captain.....Eureka
Henry Lencioni, Captain.....Santa Rosa
John Hurley, Warden, Humboldt County.....Eureka
Earl Caldwell, Warden, Humboldt County.....Eureka
W. F. Kaliher, Warden, Humboldt County.....Fortuna
Ray Diamond, Warden, Mendocino County.....Willits

Ovid Holmes, Warden, Mendocino County—Fort Bragg
Earl Macklin, Warden, Mendocino County—Ukiah
Leo Mitchell, Warden, Mendocino County—Point Arena
E. J. Johnson, Warden, Lake County—Lakeport
J. H. Groves, Warden, Sonoma County—Cloverdale
Victor Von Arx, Warden, Sonoma County—Santa Rosa
J. W. Harbuck, Warden, Napa County—Napa
R. J. Yates, Warden, Marin County—San Rafael
Bert Laws, Warden, Marin County—San Anselmo

### Southern Division

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O. P. Brownlow, Captain—Alameda
_____, Sergeant—Salinas
Ed Clements, Warden, Contra Costa County—Martinez
T. K. Duncan, Warden, Contra Costa County—Concord
C. L. Bundock, Warden, Alameda County—Oakland
C. E. Holladay, Warden, Santa Clara County—San Jose
McPherson Lough, Warden, Santa Clara County—Palo Alto
Lee C. Shea, Warden, San Francisco County—San Francisco
C. R. Peek, Warden, San Mateo County—San Mateo
F. J. McDermott, Warden, Santa Cruz County—Santa Cruz
J. P. Vissiere, Warden, San Benito County—San Juan Bautista
F. H. Post, Warden, Monterey County—Salinas
Orben Philbrick, Warden, Monterey County—Pacific Grove
F. W. Hecker, Warden, San Luis Obispo County—San Luis Obispo
L. R. Garrett, Warden, San Luis Obispo County—Paso Robles

### Marine Fisheries Detail (Coast District)

Ralph Classic, Captain—Monterey
L. J. Weseth, Master, M. V. "Albacore"—Monterey
C. M. Bouton, Warden, Cruiser "Quinnat III"—San Francisco
Otis Wright, Assistant Warden, Cruiser "Quinnat III"—San Francisco
Tate Miller, Warden—Eureka
G. R. Smalley, Warden—Richmond

## SOUTHERN DISTRICT (Headquarters, Los Angeles)

C. S. Bauder, Inspector in Charge—Los Angeles
Theo. Jolley, Warden, Flying Squad—Los Angeles
Fred Albrecht, Assistant Warden, Flying Squad—Los Angeles

### Western Division

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L. T. Ward, Captain—Escondido
_____, Sergeant—Santa Barbara
A. R. Ainsworth, Warden, Santa Barbara County—Santa Maria
R. E. Bedwell, Warden, Santa Barbara County—Santa Barbara
G. N. Johnson, Warden, Ventura County—Ventura
A. F. Crocker, Warden, Los Angeles County—Los Angeles
Walter Emerick, Warden, Los Angeles County—Van Nuys
W. L. Hare, Warden, Los Angeles County—Wilmington
H. C. Jackson, Warden, Orange County—Santa Ana
E. H. Glidden, Warden, San Diego County—San Diego

### Eastern Division

E. H. Ober, Captain in Charge—San Bernardino
_____, Sergeant—Bishop
_____, Sergeant—Banning
E. L. Walker, Assistant Warden, Mono County—Bishop
C. J. Walters, Warden, Inyo County—Independence
W. C. Malone, Warden, San Bernardino County—San Bernardino
W. S. Talbott, Warden, San Bernardino County—Pine Knot
J. H. Gyger, Warden, Riverside County—Perris
R. C. O'Conner, Warden, Riverside County—Banning

### Marine Fisheries Detail (Southern District)

C. H. Groat, Captain in Charge—Terminal Island
Walter Engelke, Master, M. V. "Bluefin"—Terminal Island
E. R. Hyde, Warden, Cruiser "Yellowtail"—Balboa
Robt. Cowell, Assistant Warden, Cruiser "Yellowtail"—Balboa
Carmi Savage, Warden, Cruiser "Bonito"—Santa Barbara
Karl Lund, Assistant Warden, Cruiser "Bonito"—Santa Barbara
N. C. Kunkel, Warden—Terminal Island
E. A. Chan, Warden—Terminal Island
L. G. Van Vorhis, Warden—Terminal Island
T. W. Schilling, Warden—San Diego
Erol Greenleaf, Warden—Terminal Island

T. J. Smith, Warden---------- Terminal Island
R. E. Tutt, Assistant Warden, Cruiser "Broadbill"---------- Santa Monica
K. H. Shebley, Assistant Warden, Cruiser "Broadbill"---------- Santa Monica
W. Scrimsher, Assistant Warden, Cruiser "Marlin"---------- San Diego
D. E. Glass, Assistant Warden, Cruiser "Marlin"---------- San Diego

## POLLUTION DETAIL

Paul Shaw, Chemist in Charge---------- San Francisco
C. L. Towers, Warden---------- Los Angeles
Wm. La Marr, Assistant Warden---------- Los Angeles
E. A. Johnson, Assistant Warden---------- San Francisco
Don Davison, Assistant Warden---------- Klamath River

## CALIFORNIA JUNIOR GAME PATROL

M. F. Joy, Warden, Superintendent Junior Game Patrol---------- San Francisco

## MARINE PATROL

Motor Vessel "Bluefin," Terminal Island
Motor Vessel "Albacore," Monterey
Cruiser "Yellowtail," Newport Harbor
Cruiser "Broadbill," Santa Monica
Cruiser "Quinnat III," San Francisco
Cruiser "Bonito," Santa Barbara
Cruiser "Marlin," San Diego
Launch "Rainbow," Sacramento
Launch "Shrapnel," Lakeport
Launch "Silverside," Eureka

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